POWER

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Why Don't They Help?

THE difficulty of getting the management to take an intelligent interest in their efforts to improve the efficiency of their plants is a constant source of complaint on the part of the engineers in charge.

On page 505 of the March 31st issue, Mr. Street tells of an engineer who pleaded in vain for some inexpensive boiler-room equipment. He had reduced the coal consumption some five tons a day by simple expedients and home-made appliances, which ought to have been an earnest that he knew what he was about and how to use apparatus if he could get it; but the manager just smiled, promised and forgot.

If a manager found that his engineer was stealing five tons of coal a day, he would have him arrested. If he knew that he was wilfully wasting five tons of coal a day, he would fire him and put on somebody who would save it. But when the engineer comes and tells him how he can save as much or more than this in the amount of coal used, he smiles and forgets.

Why? Evidently because the engineer fails to get it over. When an engineer has actually demonstrated his ability to save, he merits something more than a smile. A manager, and especially a proprietor, ought to have an intense interest in keeping expenses down and avoiding unnecessary waste. It means a better showing, a larger success for the manager and increased profits or a selling advantage or both for the owner; and the pocket nerve is usually sensitive.

And a live manager, convinced that a material saving had been made, ought at least to take an encouraging interest in the methods by which it had been done and in the possibilities of further saving that might be had through the ability and initiative and devotion of the man who did it. The engineer ought to be regarded as the responsible head of a department and given a respectful hearing on any suggestions that he may have to offer for the conduct of that department. If his suggestion is sound and he has not the ability to sell it to his superiors, that is a failing for which he is to be commiserated; but he should be given a patient hearing, fair consideration of his evidence, a chance to discuss it and a satisfying reason why his suggestion is not adopted.

F. R. Low

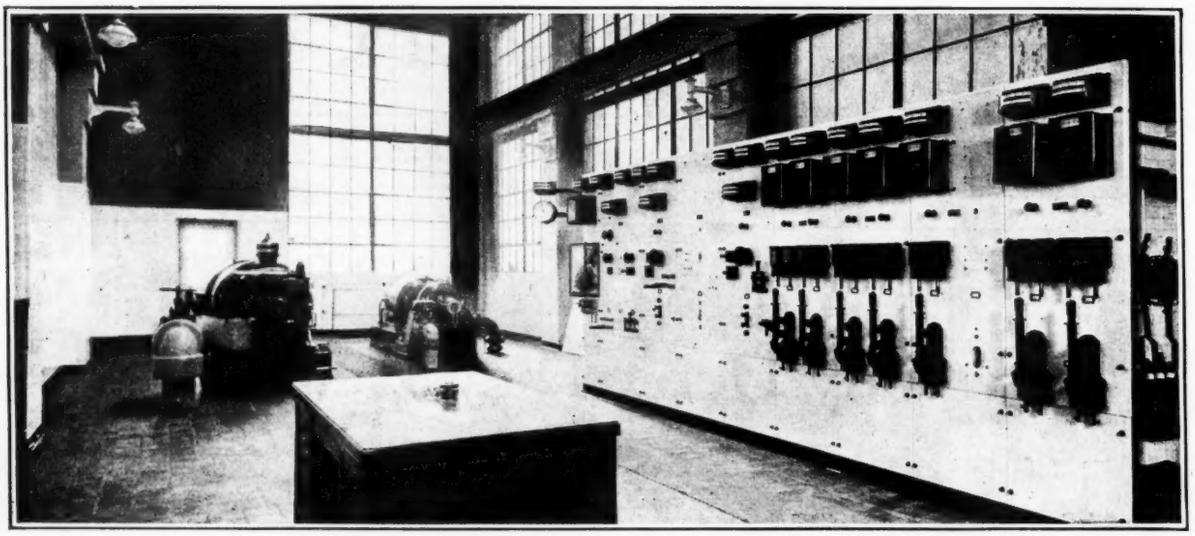


Fig. 1—General view of turbine room. Note white glass switchboard

New Plant of Pittsburgh Plate Glass Co. At Milwaukee

Non-condensing stoker-fired turbine plant for Paint and Varnish Division gives economical results in supplying power and process steam.

FOUNDED in the fifties in Milwaukee, Wis., and established at the present location in 1892, the Patton Paint Co. four years later became affiliated with the Pittsburgh Plate Glass Co. In 1921 complete ownership was acquired, and since that time the Milwaukee property has been operated as the Paint and Varnish Division. During the years the business of the division grew to enormous proportions. Plants were established at other centers, and in Milwaukee the home site has been expanded until it now occupies three city blocks containing a total of fifteen buildings. Additions have been made as required to meet the growing demands, but as is always the case in a gradual development of this character, the unit as a whole was not homogeneous. In the interests of economy a complete reconstruction plan was formulated in 1922 in which it was proposed to replace all obsolete buildings, giving eventually a layout that would be conducive to efficient production and expansion.

As the first unit, a new office building and research laboratory with five stories and basement, was built. This involved 5,500 sq.ft. of direct radiation and an equivalent amount of indirect radiation with fans and a complete air-conditioning system having steam requirements the year around. Such an addition to the steam and power requirements on a plant already overtaxed and obsolete necessitated the simultaneous building of a new plant that would meet present demands and provide for the future. This new plant has been in operation since Oct. 1, 1924, and has been giving excellent service.

At the beginning of the reconstruction period the works was served by three distinct plants, which will be designated as A, B and C. Plant A had three 800-sq.ft. return-tubular boilers about 25 years old, operating at 125 lb. gage. The power equipment was a 200-hp. Corliss engine, with a rope drive to the line-shaft in the paint factory. The exhaust steam from the engine was used for drying and heating during the season, and in summer much of it was wasted to atmosphere. Plant B contained two 1,000-sq.ft. return-tubular boilers about 20 years old and plant C, one 750-sq.ft. boiler of the same type, 25 years old. Plant B was 800 ft. from A and plant C 250 ft. from plant A. Up to 1922 the three plants had been operated independently. Coal and ash were handled manually and the operating conditions generally were not conducive to economy.

With the addition of the new office building the winter load increased so as to require the use of both A and B plants in conjunction, as all settings were low and not designed for capacities much over the nominal rating. The stacks were too small both as to height and area, and to obtain the capacity indicated, turbo-blowers were required on each boiler and the use of high-grade coal at $6.40 per ton, from which an average evaporation of 7 lb. of water per pound of coal was obtained. Excluding interest, depreciation and overhead, the steam cost ran about 58c. per 1,000 lb. The foregoing applies in general to plant C as well.

A review of the existing conditions made it clear that the boiler equipment was too old and too small to cope economically with the plant load if the additions proposed in the reconstruction plan were made; besides, the boilers were due for a cut in pressure and in any event must soon be replaced. While the Corliss engine had been maintained in good condition, it was at least as old as the boilers, so that the equipment generally was obsolete, too small and about ready for the scrap-pile.

Before any additions could be made to the factory, a new boiler plant was necessary and the other vital question to decide was whether to buy power or generate it. An analysis of steam requirements made

it evident that power generation would be more economical. Steam for some of the process work had to be supplied at 100 lb. pressure, calling for a high-pressure boiler plant. Also there was large demand for low-pressure steam for heating and drying. Past records and estimates of future requirements showed that the steam from the power load would not fulfill the demand during the heating season. In summer about half the exhaust steam could be used during the day shift of nine hours, with the probability of using the entire

From a study of the load conditions it was decided to install three 3,530-sq.ft. horizontal water-tube boilers with space for a fourth unit of the same size; one 500-kw. turbo-generator with space for a second unit of 750 kw. capacity, and a 90-kw. turbo-generator to carry the night lighting and the motor-driven drier fans.

Two of these boilers will carry the winter steam load at an economical rating, leaving one spare. One boiler will carry the large turbine for the power requirements

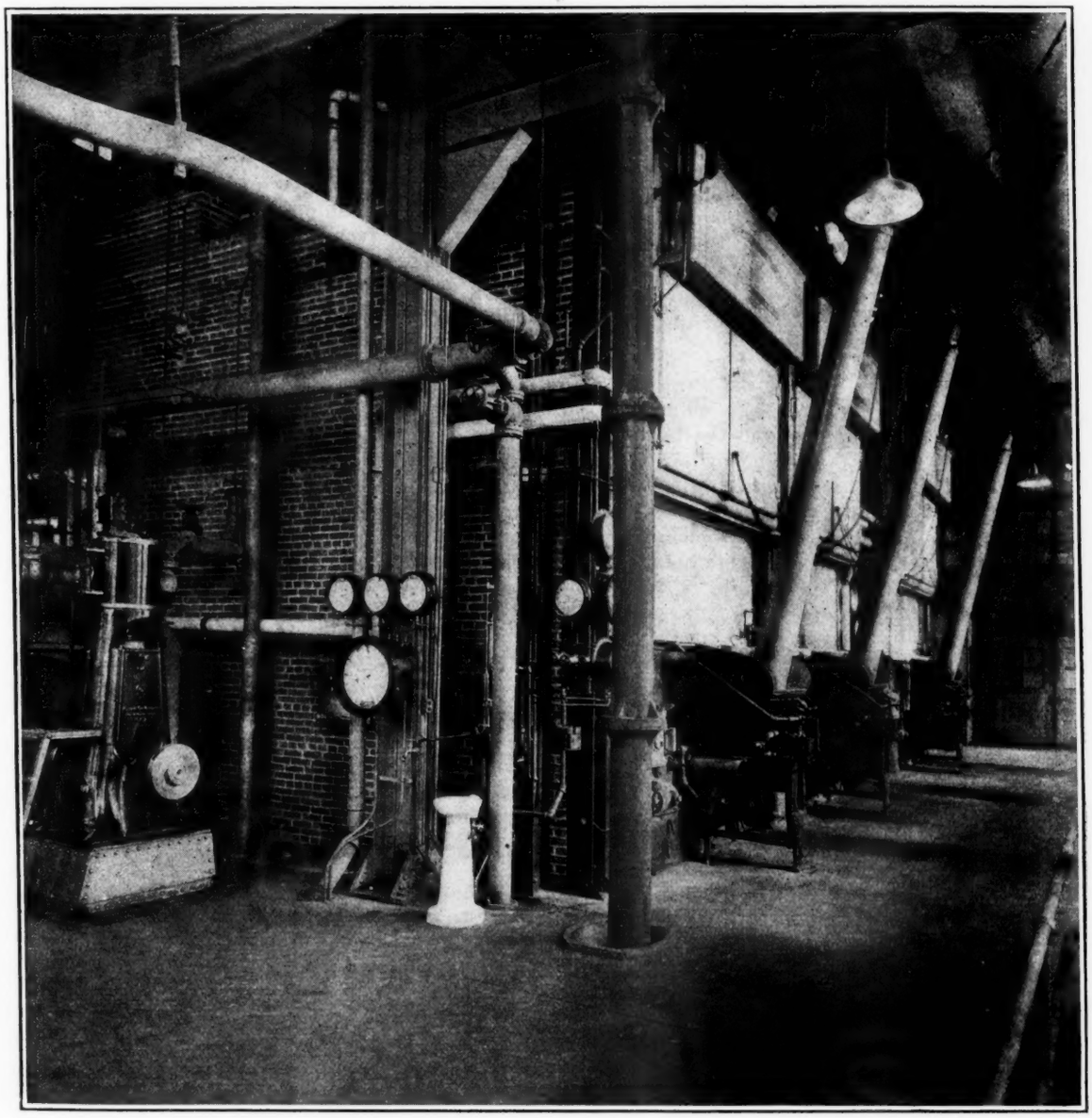


Fig. 2—Boiler installation with forced-draft fan at left

amount by installing more surface and using steam at lower pressure in some of the drying operations. During the night shift of thirteen hours, the figures showed that there would be no exhaust-steam loss either in summer or winter. With a high-pressure boiler plant already indicated, it was evident that the cost for adding generating equipment would be a small proportion of the total investment, and with power and exhaust steam requirements so nearly balanced, economy pointed to the installation of the generating plant.

during the summer at an economical overload rating, and one will supply the night load in summer and winter. During the months the plant has been in operation, these preliminary figures check closely with actual results.

As the exhaust-steam requirements for the winter months were in excess of the turbine output and as a considerable portion of the exhaust steam could be used 24 hours daily for process in the summer as against 9 hours' operation of the large turbine, it was decided

to operate non-condensing, the guaranteed steam rates ranging from 34.6 lb. per kw.-hr. at full load to 42.8 lb. per kw.-hr. at one-half load, under steam conditions of 175 lb. gage pressure, 100 deg. F. superheat and 5.3 lb. gage back pressure. With the heavy demands for exhaust steam at night, compared to the power load, a small steam-turbine with high steam consumption was selected. Guaranteed water rates under the same steam conditions as before ranged from 68 lb. per kw.-hr. at full load to 93 lb. per kw.-hr. at one-half load.

With the question of steam economy of the generating units practically eliminated by the demands for exhaust steam, the non-condensing turbines were favored over unaflow engine-driven generating units as they could be obtained at about one-half the cost, thus reducing the overhead charge.

Boilers Have High Settings

Owing to the size of the units required, water-tube boilers were selected and set high, 11 ft. from the floor to the bottom of the front tube header, to give a furnace volume of 574 cu.ft. over the grate to the bridge wall and a total volume in the combustion chamber of 1,020 cu.ft. This large volume was particularly desired, as there was the possibility of burning oil and a certainty of burning screenings.

Operating conditions are a steam pressure of 175 lb. gage and superheat of 100 deg. F. obtained from radiant-type superheaters just behind the bridge wall. The gases pass to a concrete stack rising 175 ft. above the grates and 8 ft. in diameter at the top. This stack was figured for a maximum of eight boilers instead of four, to provide for future load development.

For burning the lake coal usually obtainable, underfeed stokers were selected. For medium capacities the particular type installed is popular in this section, as these stokers seem to burn with equal facility inferior coals of wide variety. The claim is made that since the new plant has been placed in operation nearly all grades of fine coal have been burned with the exception of coke braize, including a mixture of anthracite and bituminous screenings.

In the furnace settings No. 1 brick have been employed throughout, and after erection the settings were air dried for 60 days. As a result, during the six months of operation, there has been no spalling and no trouble of any kind with the refractories.

Forced draft is supplied by an oversize slow-speed fan with a capacity of 31,500 cu.ft. per min. against a static pressure of 5 in. This large slow-speed unit was selected to keep down maintenance charges and for reliability, as there is no reserve unit. The fan drive, however, is in duplicate, consisting of a 38-hp. vertical engine at either end of the fan shaft. Only one engine at a time is coupled to the fan, but the change from one to the other can be made in a few minutes, should this become desirable, without interrupting operation. Air and coal to the boiler are regulated automatically by damper regulators functioning from variations in steam pressure. These regulators have chain connections to the uptake dampers and to the steam supply for the stokers as well as fan engines.

Welded steel piping for all sizes larger than 4 in. has been employed, with cast-steel fittings and standard high-pressure steel valves monel fitted. One of the features of the piping system is the placing of the non-return and the gate valves in the boiler leaders within easy reach of the floor, where they are subject to daily inspection and test.

The plant is well equipped with instruments both in the boiler room and the turbine room and all departmental steam and power are metered. The instruments are within easy view of the firemen at the front of the settings. For each boiler there are the indicating instrument of the steam-flow meter, an indicating pressure gage, a recording pressure gage on the header, a three-in-one draft gage, recording thermometers for uptake temperatures and steam temperatures and a recording pressure gage on the blowoff to show the time and duration of the blowing and give a check on when and by whom the work is done. This arrangement will also indicate any steam leakage. There is a feed-water meter of the orifice type, a CO_2 recorder that can be used on any one of the three boilers and counters on the stokers for checking the amount of coal fed to the individual boiler. In the absence of coal scales the railway and shipper weights are used.

City water from Lake Michigan is used in the plant, and although this contains only 8 to 14 grains of incrusting solids per gallon, it was decided that a water-softening plant would be a paying investment, as it would practically eliminate scale deposits within the boilers. It may be added here that after six months of operation, there is no sign of scale on the metal. The hot-process system, with an open heater and softener, using soda ash and lime as the chemicals, was selected. The installation has a heater capacity of 6,000 gal. per hour and a raw-water capacity of 4,000 gal., with a guarantee that the softened water will not exceed 1½ grains of hardness per gallon. Although where possible the returns are brought back from the manufacturing plant, the makeup at present averages about 25 per cent, owing principally to the use of open steam jets in some of the process work.

From the softener the treated water passes through a sand filter to either one of two simplex boiler-feed pumps which supply the boilers under the control of feed-water regulators and pump governors. The feed-water meter is on the suction side of the pump, and is equipped with a standpipe to reduce the pulsations to a minimum.

White Glass Switchboard Employed

A novelty is switchboard panels made of white Carrara glass 1¼ in. thick with a black glass mopping base. The glass panels are backed by ¼ in. of transite on which all small wiring is mounted to prevent injury to the glass from local heating from wires or studs. The glass panels are supported by pipe framework and carry no weight other than the instruments mounted upon them. The oil switches are mounted on separate framework independent of the glass, the generator oil switches being in the basement and equipped for remote control.

The instrument equipment of the board is unusually complete for a plant of the size, including, in addition to the usual ammeters and voltmeters, a Tirrell regulator, a synchroscope, a power-factor meter and recording watt-hour meters. On the feeder panel there are indicating and recording watt-hour meters which give the current consumption of each department. In the turbine room there is also a special flow-meter board containing the recording and integrating instruments of the steam-flow meters in the boiler room and on the service to the different departments. Another feature

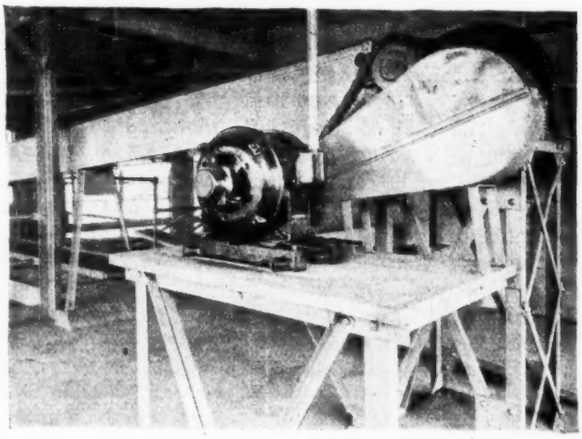


Fig. 3—Chain drive for two screw conveyors

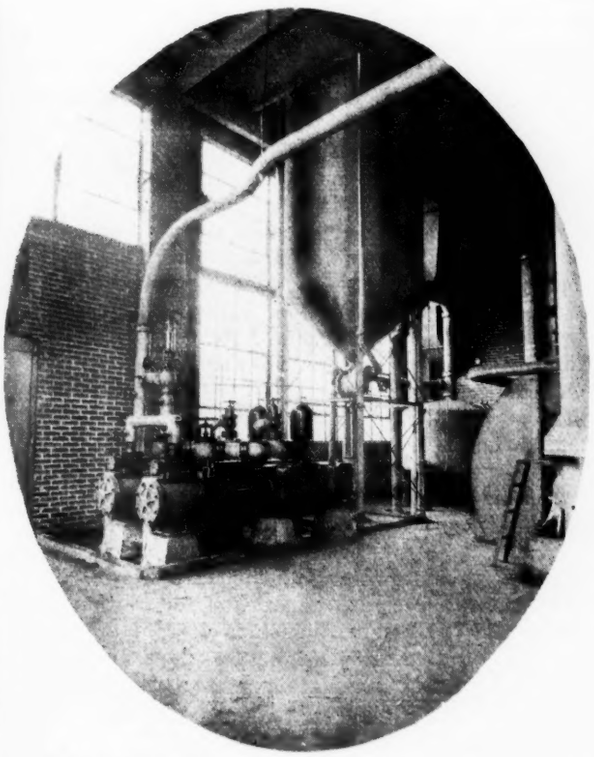


Fig. 6—Heater and filter of hot-process softener

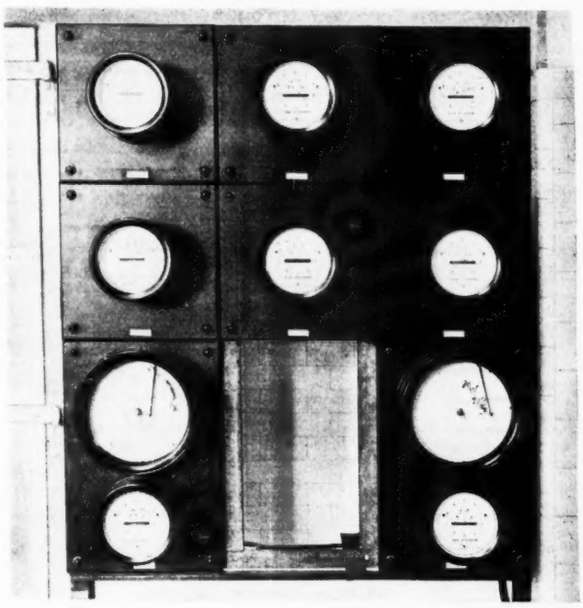


Fig. 4—Flowmeter board in turbine room

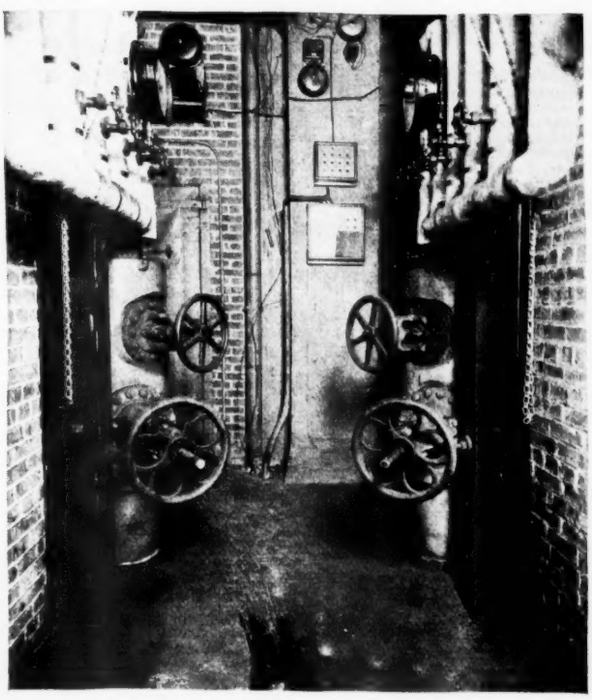


Fig. 5. Left—Mixing tanks and part of softener

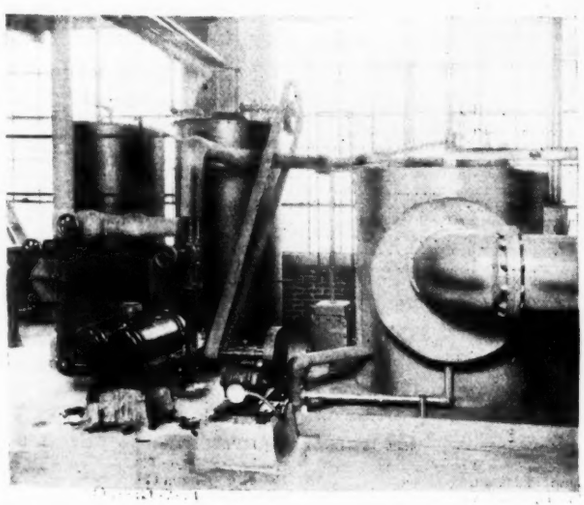


Fig. 7. Above—Non-return, gate and feed valves, located close to the floor

in the turbine room is the installation of the control equipment for the fire alarm and watchman's auto call system. This gives control of emergency situations involving power lines, sprinkling system, etc., from a central point where somebody always must be present.

Mention has been made of the generating equipment, consisting of 500- and 90-kw. turbo-generators operated non-condensing at a speed of 3,600 r.p.m. in each case. Each machine has a direct-connected exciter. The back pressure varies from 2 lb. in the summer to 7 lb. in winter when the demand for exhaust steam is particularly heavy. Current is generated at 220 volts. Owing to the heavy current at this low voltage, the generator leads are made up of three 2-in. extra-heavy copper tubing which take the place of nine 1,000,000-cm. cables. All fittings are sweated into the tubes to give a continuous, solid copper circuit.

For its operation the plant requires the services of four men, an engineer and fireman on each of the two shifts. This includes the handling of coal and ash. Once a week an extra man is called in to perform odd jobs, but essentially the installation is a four-man plant.

Operating figures for March, which are now available, show that the electrical generation for the month amounted to 115,223 kw.-hr., which is divided up into 24,375 kw.-hr. nights and 90,848 kw.-hr. days. On the basis of a 25-working-day month, these figures in round numbers reduce to 1,000 and 3,600 kw.-hr. per night and day, respectively, or a total of 4,600 kw.-hr., which may be compared to 4,400 kw.-hr., the previous estimate.

Out of a total of 12,981,230 lb. of steam generated, the turbines used 4,774,000 lb. With one boiler banked at night, the coal consumption amounted to 1,562,000 lb., giving an average evaporation of 8.3 lb. of water per pound of coal. The coal cost averaged $4 per ton. Boiler efficiency for the period averaged 74 per cent, an excellent figure considering the size of the plant and the quality of the fuel used. The generating cost per 1,000 lb. of steam, including all operating charges and overhead, averaged approximately 52c., as seen in the accompanying table:

Fuel, labor, maintenance repair and supplies	$4,526.66
Interest and depreciation	1,616.00
Overhead	614.27
Total monthly cost	$6,756.93
Steam generated, lb.	12,981,230
Cost of steam per 1,000 lb.	$0.52

Preliminary building plans and plant layout were prepared by Cahill & Douglas, consulting engineers, of Milwaukee, and followed through by V. K. Boynton, chief engineer of the Paint and Varnish Division, under the general direction of Ludington Patton, vice-president, and C. H. Hall, divisional director. John Brœcker is chief operating engineer of the plant.

DATA ON EQUIPMENT IN PLANT OF PITTSBURGH PLATE GLASS COMPANY

Boiler-room dimensions, inside ft.	40 x 84
Distance basement floor to boiler-room floor, ft.	12
Height from boiler-room floor to roof trusses, ft.	48
Width of firing aisle, ft.	12
Ratio boiler heating surface to floor area (including future boiler)	4.2 to 1
Turbine-room dimensions, ft.	21 x 60
Distance basement floor to turbine-room floor, ft	12
Height turbine-room floor to roof trusses, ft.	21

BOILERS AND SUPERHEATERS

Manufacturer	Heine Boiler Co.
Number	3
Number of passes	3
Heating surface, sq.ft.	3,530
Working pressure, lb. gage	175
Superheat at normal rating, deg. F.	100
Steam temperature, deg. F.	477.5
Superheaters, Foster radiant type	Power Specialty Co.
Square foot water-heating surface per kilowatt	10.59

STOKERS

Manufacturer	Combustion Engineering Corp.
Type No. 3 heavy duty, Type E, single-retort, underfeed designed for 200 per cent of boiler rating.	
Grate area, sq.ft.	68
Water heating surface to grate surface	52.1

FORCED-DRAFT FAN

Manufacturer	Clarage Fan Co.
Number installed	1
Type	¾ housing, single width, double inlet
Capacity, cu.ft. per min. at 5-in. static press.	31,500
Speed, r.p.m.	342
Drive, two 38-hp. vert. engines, 8x8 in.	Clarage Fan Co.

STACK

Builder	Heine Chimney Co.
Type	Concrete
Diameter at top, ft	8
Height above grate, ft.	175

PUMPS

Boiler feed, two simplex, 12x18x14 in., Adkins, Young & Allen Co.	
Type	Outside packed, mine pattern
Vacuum pumps, two Marsh 10x14x16 in.	American Steam Pump Co.
Type	Bronze fitted wet vacuum pumps
Sprinkler pump, 2-in. cent., 10-hp. motor, 1,800 r.p.m	Allis-Chalmers Mfg. Co.

FEED WATER HEATER AND SOFTENER

Manufacturer	Power Plant Specialty Co
Type	Hot process
Chemicals	Lime and soda ash
Heating capacity, gal. per min.	6,000
Raw water capacity, gal. per min	4,000

WATER METER

Manufacturer	Cochrane Corp.
Type	Orifice, 4 in.
Capacity lb. per hr. at 215 deg. F.	40,000

COAL HANDLING

Manufacturer	Jeffrey Manufacturing Co.
Capacity of system, tons per hour	25
Track hoppers	Two 12x12 ft.
Double plate feeder	27 in. x 15 ft.
Crusher	Single roll, 24 x 24 in., 60 r.p.m.
Drive—15-hp. Allis-Chalmers ind. motor, 860 r.p.m.	
Belt conveyor, 5-ply, 16-in. belt with ⅛-in. rubber covering 68 ft. between centers, 25 tons per hr. at 200 ft. per min., drive 7½ hp. Allis-Chalmers ind. motor, 860 r.p.m.	
Bucket elevator, 14x7 in. buckets on 24-in. centers, 52 ft. between centers, 25 tons at 200 ft. per min., drive same motor as for belt conveyor.	
Screw conveyors, two 12-in., diam. 38 and 60 ft. long, 45 r.p.m., drive for two conveyors 10-hp. Allis-Chalmers ind. motor, 860 r.p.m.	
Three driving motors interlocked electrically.	

ASH CONVEYOR

Manufacturer	Conveyors Corporation of America
Type	Steam jet
Dimensions	8-in. line, 110-ft. hor. run, 50-ft. vert. run.
Tank	Steel, inside concrete lined, 6x8 ft. and 16 ft. high

TURBO-GENERATORS

Manufacturer	Allis-Chalmers Mfg. Co.	
Number	2	
Capacity at 80 per cent p.f., kw	500	90
Speed, r.p.m.	3,600	3,600
Guaranteed water rates, full load (noncond.)	34.6	68
Lb. per kw.-hr.; op. noncond., ¾ load	37.3	76
175 lb. gage, 100 deg. F. superheat, 5.3 lb. back pressure, ¾ load	42.8	93
Generators	3 phase, 60 cycle, 240 v.	
Exciters	Direct-connected, 110 v. 56 and 40 amp.	
Air washer for large machine, unit type, 2,500 cu.ft. per min.	Mid-West Filters	

MISCELLANEOUS MECHANICAL EQUIPMENT

Traveling crane, 10-ton hand	J. C. Busch Co.
Damper regulators	Ruggles-Klingemann Mfg. Co.
Soot blowers	Bayer Co.
Feed-water regulators, copes	Northern Equipment Co.
Pump governors	Fisher Governor Co.
Steam traps	C. E. Squires Co.
Valves, steam and water	Chapman Valve Mfg. Co.
Valves, feed-water	Lunkenheimer Co.
Valves, nonreturn	Schutte & Koerting Co.
Valves, blowoff	Everlasting Valve Co.
	Yarnall-Waring Co.
Valves, safety	Ashton Valve Co.
Piping	M. J. Dougherty Co.
Pipe covering	Johns-Manville, Inc.
Water columns	Davidson
Steam flow meters	Republic Flow Meters Co.
Pressure gages	Ashton Valve Co.
Recording gages	Foxboro Co.
Draft Gages	Foxboro Co.
CO_2 recorder	Foxboro Co.

ELECTRICAL EQUIPMENT

Switchboard, 8 panel	General Electric Co.
Graphic recording meter	Esterline-Angus Co.
Panels, carrara glass	Pittsburgh Plate Glass Co.

Increasing Financial Efficiency by Simplification of Plant Design

By H. M. VEHLING and H. S. CRAWFORD

DURING the last few years the attention of designing engineers has been concentrated upon the subject of thermal efficiencies, which incidentally represents only *one* of the many factors that determine the cost of power. Any net gain derived from an increase therein is the money saved in fuel less the additional expense incurred in effecting this saving. Accordingly, when we express an increase in thermal efficiency in terms of increased financial efficiency, we encounter the fact that each material saving thus effected is always accompanied by additional equipment, maintenance and labor costs and that there is a limit to the thermal efficiency that it is practical to obtain.

As a solution to this problem is near at hand, it is now in order to turn to factors other than those that affect operating expense only and consider some of the remaining items that determine the cost of power, such as initial investment and fixed charges. Decreasing the initial investment through refining power-plant design by means of compactness is the theme of this article. Compactness of design may be defined as higher power-generating capacity per cubic foot of building content and may be obtained by the elimination of ponderousness and by increasing the heat-absorbing capacity of the steam-generating unit. This latter item, however, will not be considered here.

IN STEAM power-plant design, as in other things, there is a tendency to follow the crowd blindly. One takes it for granted that the breeching must be above the boiler. Clumsy structures, scattering of equipment and useless cubical building content cause no dismay. "That is the way it is meant to be—the way it always has been." The time is over-ripe to cease taking these things for granted. One should be willing to build the plant upside down if that is the best way to do it. The authors attack the problem of boiler-room arrangement boldly and broadly and suggest similar studies of the entire plant. If this article does nothing more, it will promote a lot of fundamental thinking that cannot fail to clarify the technique of power-plant design.

The application of compactness to power-plant design has generally been overlooked although its possibilities are as great as those obtained by the recent improvements in thermal efficiency. This statement is substantiated by the fact that in a representative group of present-day modern power plants, the boiler-room cubical content ranges between the limits of approximately 12 and 26.5 cu.ft. per square foot of installed boiler-heating surface. Knowing that each cubic foot of building space incurs just as definite a cost as any other item used in power-plant construction and that nothing can be gained by wasting cubical content, it is in the elimination of all unnecessary space and in the skillful use of construction materials that a substantial reduction in initial investment may be obtained.

As by far the greatest improvement can be made in the boiler room, the present article is restricted to a consideration of this section of the plant. It will be shown how the building cubical content can be reduced to the remarkably low figure of 6.4 cu.ft. (7.9 cu.ft. including pulverizing plant) per square foot of installed boiler-heating surface without crowding any of the equipment. With the cost of structures representing from 15 to 30 per cent of the total cost of a modern power plant, which in turn fixes the cost of each cubic foot of building content at from 25 to 50 cents, the effect that this reduction in space will have on initial investment is obvious. It is to be noted that any saving obtained by means of compactness is 100 per cent applicable as an increase in the financial efficiency of the station.

To develop this feature a study of the different typical boiler-plant designs will be made and it will be shown how the unnecessary buiding space and materials, as evidenced in each type, can be eliminated and a design developed that will, without crowding any of the equipment, slightly increase the thermal efficiency and greatly reduce initial investment.

The path of the products of combustion has had an important influence on boiler-room design. The designer has given the waste gases preference over all the other heat-conveying fluids used in the heat-liberating, absorbing and conveying process and in doing so has overlooked the resulting dispersement of equipment and ponderousness of structures. The existing types of boiler room may be classified as follows: The overhead-gas outlet type, the side-gas outlet type and the side-bottom gas outlet type. The principal features of each of these designs will be briefly considered and it will be shown how the financial efficiency can be improved upon by a true bottom-gas-outlet design.

In plants of the overhead gas-outlet type the economizer, induced-draft fan, breeching, flue ducts and self-sustaining smokestack are located above the boiler and above each other, with the stack extending upward from the roof. This design originated through taking advantage of the draft-creating capacity of the ascending hot gases. Its creditable features are: Maximum obtainable natural draft, stack reduced in height equal to height of the roof above the combustion chamber and comparatively small projected ground area. Its disadvantages are: High first cost, excessive cubical content,

high center of gravity, excessive cost of heavy steel members to support tons of equipment located high above the boiler settings and to withstand the tremendous wind-pressure moment caused by the self-sustaining smokestacks, objectionable operating conditions caused by poor lighting and ventilation and congestion of equipment. This latter condition has been acknowledged in some of the recent installations in which the breeching is placed above the boiler-room roof in order to relieve congestion and to prevent overheating of the upper boiler-room air. Since a station can be designed with a ground area equal to that of the overhead gas-outlet type without having any of its discreditable features, it is inconceivable that such a large capital outlay has been made in so many plants merely to obtain a negligible increase in draft.

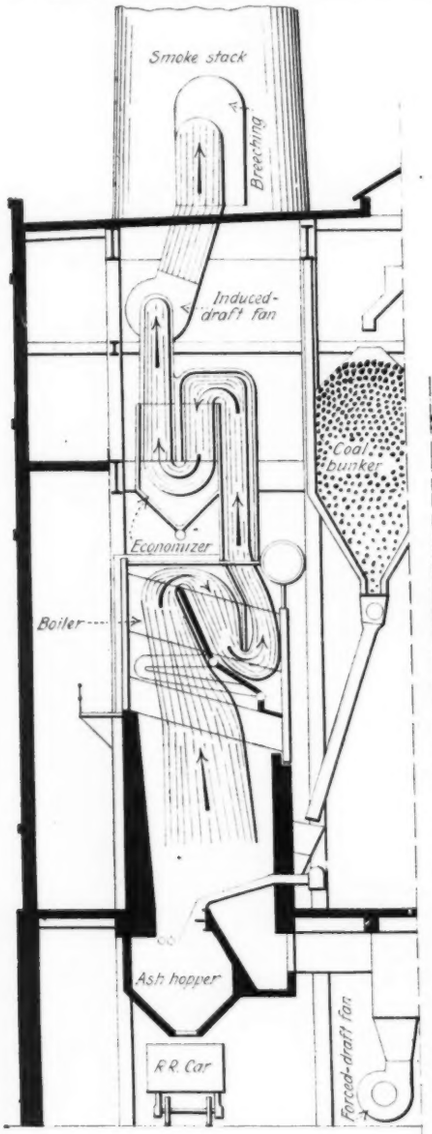


Fig. 1—Sketch of overhead-gas-outlet type

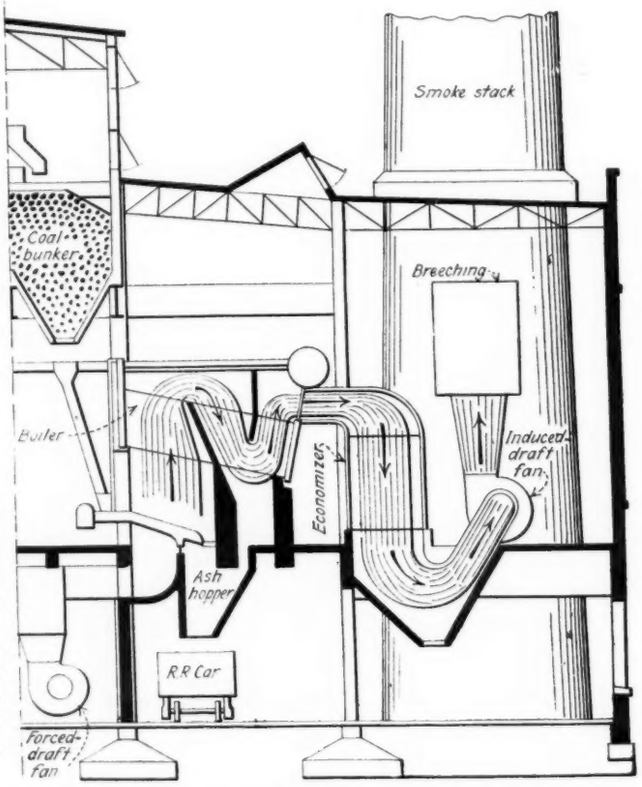


Fig. 2—Sketch of side-gas-outlet type (same scale as Fig. 1)

The Side-Gas-Outlet Type

In the side-gas-outlet design the path of the gases, upon leaving the boiler, is through the rear wall of the setting, through economizer, fan, breeching and flue ducts, likewise located in the rear of the boiler, to smokestacks inside or outside of the boiler room with stack foundations in the ground. Its creditable features are: Reduced height of structures, low center of gravity, very light supporting steelwork, also excellent lighting and operating conditions. The objectionable features are: Large cubical content and large projected ground area. High real-estate values or adverse foundation conditions limit the application of this design.

The Side-Bottom Gas-Outlet Type

The side-bottom gas-outlet design is an improvement over the foregoing plant in that the economizer is either located beneath the last pass of the boiler with fans and flue ducts in the rear, or it is in the rear of the boiler setting with fans and flue ducts directly beneath. This design incorporates all the creditable features of the side-gas-outlet type and requires a building of much less cubical content and projected ground area, owing to the width of the boiler room being greatly reduced. Its projected ground area is greater than that of the overhead gas-outlet type, although its cubical content is much less. High real-estate values or adverse foundation conditions may likewise limit the application of this design.

It may be said of all the above-mentioned types that much waste space exists below the boiler-room floor line. In the stoker-fired plants this condition has resulted from the method used in effecting ash disposal. In most cases it has been customary practice to provide large ash hoppers suspended from the boiler-room steelwork with clearance below to accommodate standard railroad cars. Pulverized fuel with its accompanying

simplified ash-disposal problem permits of the combustion chamber being dropped into the basement where it is commercially more efficient, due to the space being used jointly for heat liberation and ash disposal.

The True-Bottom Gas-Outlet Type

Considering the various advantages of the latter plant it is evident that the development of a true bottom-gas-outlet design promises the best possibilities for further increasing the finanical efficiency of the station. This proposed design differs from the other plants in that the gases of combustion upon leaving the boiler are directed vertically downward into the economizer, through the induced-draft fan, breeching and flue ducts which are placed directly below each other and in the same boiler setting. Referring to the accompanying cross-section, it is to be noted that the combustion chamber, boiler and all auxiliary equipment form a complete steam-generating unit in which building space, construction materials and radiation are reduced to a minimum and in which a heat exchange between the outgoing flue gases and the incoming air is ingeniously effected. It is to be noted that the whole design is conservative and that the method of arranging the equipment is a sound and logical one.

The steam-generating unit is arranged in a minimum of space due to making the auxiliary equipment, with the exception of the induced-draft fan, integral with the boiler setting. The equipment is readily accessible, and sufficient space is left for convenient walkways and withdrawal of soot-blower elements and economizer tubes. Waste space from roof to basement floor line is greatly reduced without affecting the steam-generating unit. Advantageous features of this design are as follows: Small first cost, minimum cubical content, projected ground area equal to that of the most concentrated overhead type, low center of gravity, light steelwork, small floor areas, excellent lighting and ventilating conditions.

Having mentioned some of the design features of this plant, its thermal features will now be considered. Radiation has been practically eliminated by placing the auxiliary equipment within the same boiler setting and separating their exposed surfaces from the boiler-room air. This idea of eliminating radiation losses has been carried still further by lowering the surface temperature of the entire steam-generating unit by circulating a heat-absorbing fluid, such as air, steam or water between the exposed surfaces and the high-temperature zone. This has been accomplished by using existing present-day features such as an air-cooled setting wall and a tube-cooled boiler roof in combination with new features which are: The replacement of the customary refractory arch with a radiant-heat superheater, the extension of the economizer heating surface to form a roof-cooled passage for the outgoing flue gases between boiler and economizer proper and the conversion of the flue duct into an air preheater. These principles appear for the first time in this design.

The radiant-heat superheater-arch continues this fluid-cooled principle up to the front boiler drum. The boiler drums and boiler roof tubes extend this feature to the last gas-outlet passage of the boiler. A continuation thereof is manifested in the secondary economizer, the tubes of which are curved to form a roof passage for the outgoing flue gases. The economizer proper extends this cooling action practically down to the induced-draft fan. The only portion of the steam-

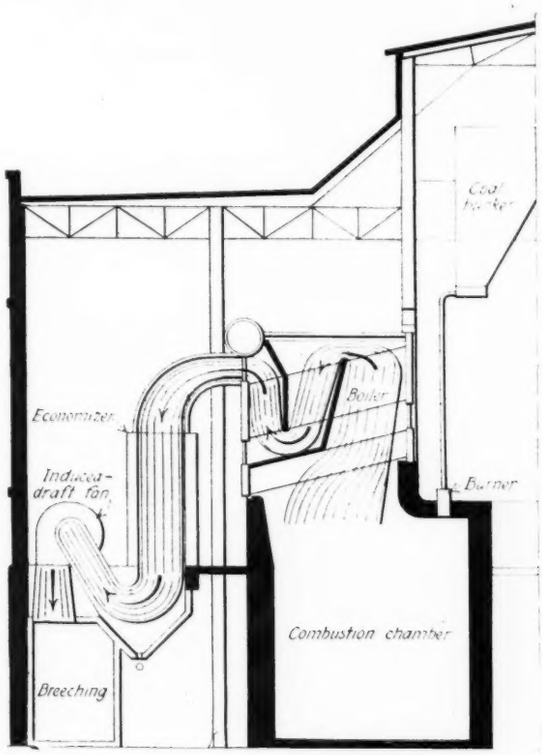


Fig. 3—Sketch of side-bottom gas-outlet type (same scale as Fig. 1)

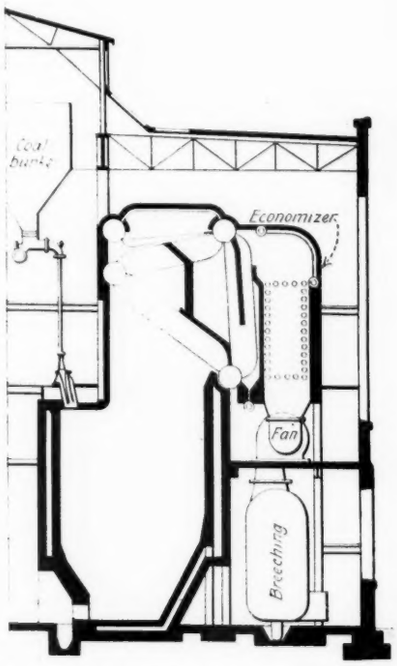


Fig. 4—Sketch of true bottom-gas-outlet type (same scale as Fig. 1)

generating unit not thus cooled is the distance between the economizer outlet and the boiler-room floor. It will be noted that the breeching is suspended in an inclosed air space through which the air for combustion is drawn and heated on its way to the combustion chamber. The heat-exchange features incorporated in this design makes it possible to utilize the breeching as an air preheater at no additional cost.

The arrangement of the mechanical equipment in accordance with this true bottom-gas-outlet design effects

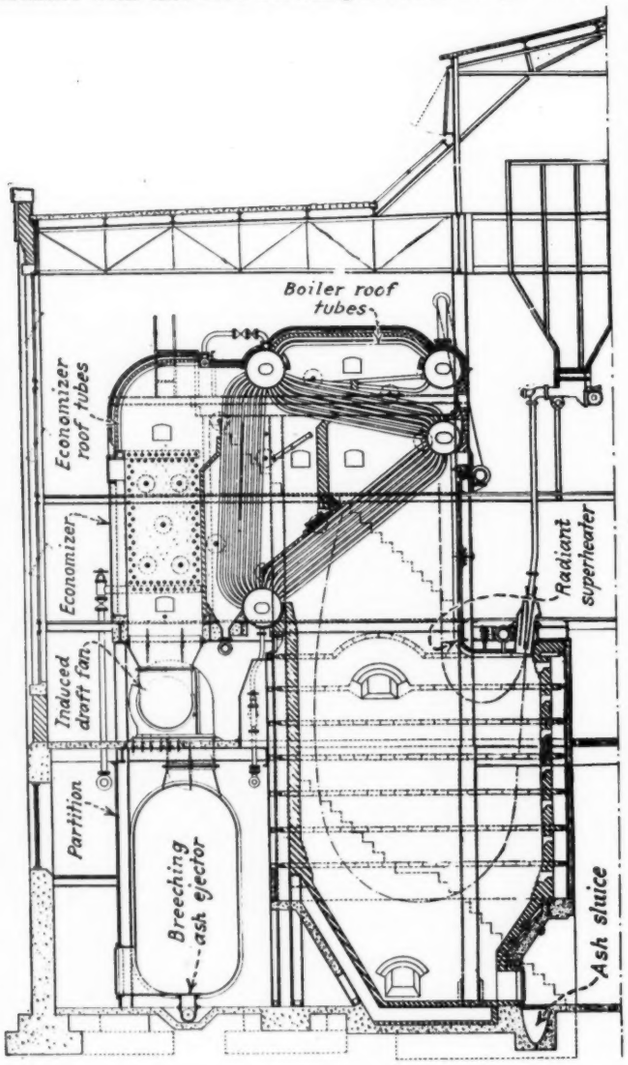


Fig. 5—Sectional elevation of plant with true bottom gas outlet

a reduction in initial cost as follows: (a) A saving by a reduction in building cubical content which is due to the difference in design of the boiler rooms compared; (b) a saving by eliminating ponderousness in the boiler-room structures only which is due to using a more refined design and reducing the amount of construction materials to a minimum; (c) a saving by eliminating ponderousness in the placing of mechanical equipment and by the replacement of certain equipment with apparatus capable of serving dual purposes, and (d) a saving due to an increase in thermal efficiency effected by the heat exchange and heat-reclaiming capacities of essential power-plant apparatus creditable to its special location. A careful estimate has shown that the sum of the savings thus possible amounts to slightly more than 10 per cent of the total value of a power plant of average cost.

Having pointed out how the financial efficiency can be improved by the elimination of unnecessary building content and construction materials, simplification of design and replacement of certain pieces of apparatus by other equipment and their adaption to serve dual or even triad purposes, such as the radiant-heat superheater serving as an arch, the breeching as an air preheater, the economizer roof tubes serving as a gas passage support, heating surface and feed-water piping, the combustion chamber as an ash hopper, etc., the full value and superiority of the true bottom-gas-outlet plant[1] is realized.

The principle of compactness of design, as developed in the proposed boiler room, may in a different form be extended to cover the structures and equipment of the entire power plant. In view of the magnitude of the saving thus possible, it may justly be said that this article opens up an entirely new field, the development of which will materially reduce the cost of power produced by the steam power plant.

Steam-Turbine Foundations

To design foundations for four or five times the machine weight makes them unnecessarily strong with respect to perpendicular forces, while possibly failing to secure safety in other respects. Dynamic forces, whether due to short-circuit on the generator or to unbalance in the rotating parts, cause higher stress than equal static forces. If the period of the dynamic forces coincides with the natural period of vibration of the foundation, the latter is set into dangerous oscillation regardless of the magnitude of the dynamic forces.

Though the set be perfectly balanced in the first place, unbalance may be introduced by unequal wear or stripping of blades, or by displacement of the generator field coils. The packing rings initially have a clearance of about 0.004 in., which may be increased by wear to 0.02 in. before the shaft becomes seriously heated by friction. Under these conditions the unbalanced centrifugal force may become very high. As this force is dynamic, it produces about twice the stress produced by an equal static load. As it acts in all directions in turn, the foundations should be designed for a vertical load equal to twice the total weight of the set and for a transverse force equal to the total weight of the machine. The latter requirement may involve heavier supports, in the case of high foundations, than would be indicated by designing for a vertical load equal to four or five times the weight of the machine. The natural frequency of the foundation should differ at least 30 per cent from the machine speed.—*Zeitschrift des Vereines deutscher Ingenieure.*

Many of the inclosed crankcase splash-lubricated engines are not equipped with any sort of filtering apparatus, and the oil never gets cleaned at all except when the engine is shut down. Then some of the moisture and sediment will separate, but it is usually stirred up again as soon as the engine is started. An oil for such a system should be as highly filtered and as carefully refined as a steam-turbine oil; in fact, a turbine oil is frequently used.

[1]As this information has become available through a considerable amount of work extended over a long period of time, the novel features have been covered by patent rights applied for.

Power-Plant Instruments

Typical Arrangement of Indicating, Integrating and Recording Instruments for the Steam End of a Power Plant with Suggestions for Their Selection and Installation

By R. S. REED
Stone & Webster, Inc.

THE demand for suitable instruments for the modern power station during the last twenty years has developed quite as rapidly as for the principal equipment served by them.

From the time when a few pressure gages were sufficient for hand-fired boilers and slow-speed engines, this equipment has been developed to the point where the operation of each important unit in the station is governed from or controlled by the accurate functioning of suitable instruments. It follows that the importance of this equipment has grown apace and the day has passed when an ornate gage board is installed as a concluding flourish of the engine builder, or when a pressure gage of doubtful quality is hurriedly placed on a pipe line in order to detect an abnormal operating condition.

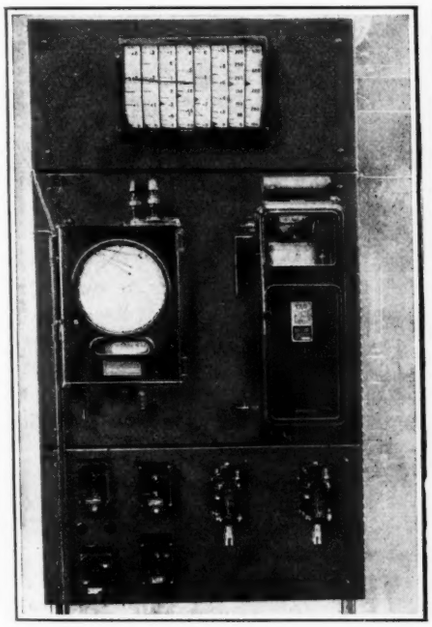


Fig. 1—Individual boiler panel

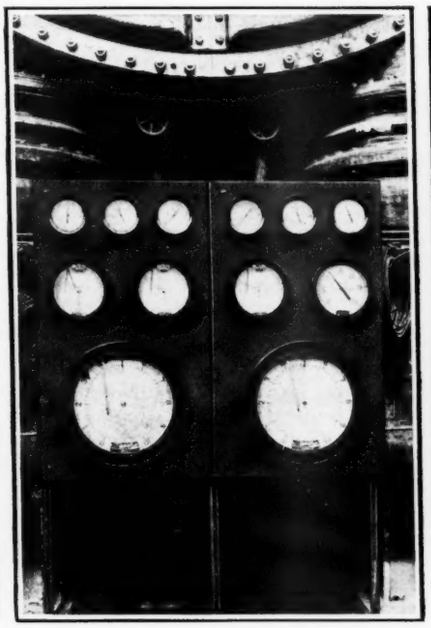


Fig. 2—Condenser gage board

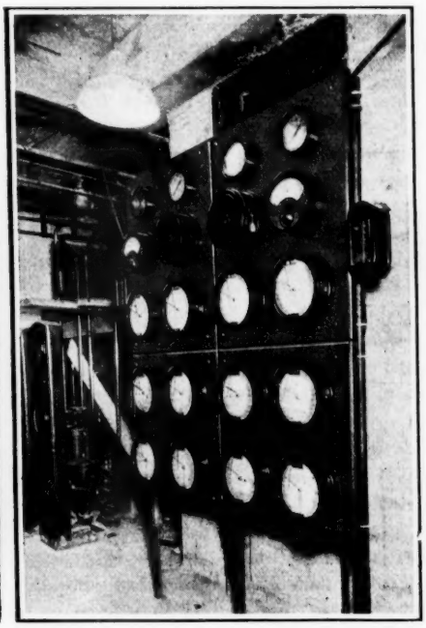


Fig. 3—Boiler-feed gage board

The selection and arrangement of the instrument equipment should be made by the designing engineer during the early stages of the plant design for several reasons:

Certain electrically operated instruments will require conduits for accommodating their connecting wires. The construction of these conduits usually precedes the pouring of the concrete floor mats or setting of tiling or brick flooring.

In certain cases, particularly where some instrument is remotely located, it may be necessary to provide wall or floor thimbles through which the leads serving these instruments can be run. These thimbles must be provided and installed prior to installation of the adjacent concrete or brickwork.

The design of the main steam and water lines must include correctly located flanges so that the orifice plates, nozzles, and venturi tubes will be situated with proper respect to the location requirements imposed by the manufacturers of these flow meters.

Still another important detail exists where the employment of high line pressures requires suitable bosses on the piping or fittings in order to provide mechanically strong and pressure-tight connections for the small pipe lines serving the instruments. These bosses can be provided at the pipe fabricator's factory for a nominal additional sum, rather than attempting to weld on the bosses in the field at a later date with possibly indifferent results and certainly at a higher cost.

It may be well to set down in a general way certain details applying to different types of instruments which should be borne in mind in connection with the selection and purchase of such equipment. Notwithstanding that some of these details are apparently elementary and obvious, they are at times lost sight of during the mass of work attendant upon more important and pressing details of the design and construction of the power plant.

Pressure Gages

On the basis of over-all dimensions and dial sizes pressure gages for power-plant service can be classified under two general heads:

1. Gages equipped with large size or special dials for observing from distances the pressure conditions in boilers and other equipment.

2. Small or standard size gages usually about five or six inches in diameter for installation on pipe lines and on various equipment.

In the first class will fall the steam gages for individual boilers and master gages. Wherever practicable internally illuminated dials are recommended, especially for master or pilot gages, owing to the distance from which the scales must be observed. For this class of service gages also are usually provided with limited or suppressed scale ranges so that small pressure fluctuations are interpreted by a relatively long pointer movement. Their location with respect to the source of pressure indicated will, in general, require that attention be given to adjustment for differences in elevation. This obviously applies to any type of pressure gage when used for indicating liquid or condensable fluid pressures.

Where pressure gages are mounted on panel boards with other instruments, it is often possible to have the instrument-maker mount them in cases identical with those in which recording thermometers and other instruments are provided. This feature costs little additional and greatly enhances the general appearance of the boards.

It is well to use pipe connections not under ½ in. for pressure gages, especially where remotely located, and for connection to vacuum gages the minimum pipe size should be ¾ in. to avoid possible errors from accumulations of condensate in the connecting piping.

Often the use of the duplex type of pressure gage will be desirable for indicating related pressures such as the entering and leaving pressure. This type of gage consists of two separate Bourdon coils and pointers mounted concentrically upon one scale plate.

Recording Pressure Gages

With respect to recording pressure gages, it is especially important to select a chart range capable of showing a legible record for normal pressure conditions and yet provided with a total range sufficient for all possible pressure peaks. Sometimes a reversed or inverted scale chart will be useful where the zero line on the chart is placed at the outer circumference and the maximum line is placed toward the center of the chart. For example, a chart for recording a pressure normally running at 2 or 3 lb. may at times be called upon to record peaks of 15 to 20 lb. This is a case where an inverted scale is desirable, as the normal record will be located near the outer or "open" part of the chart.

Indicating Thermometers

The selection of these instruments is governed to a large extent by the pipe-line layout and available location for the thermometer bulb sockets. In all cases separable sockets should be employed to permit the removal of the sensitive bulb without interfering with the flow of liquid in the pipe line. The separable socket should be constructed of the metal most suitable for service in connection with the particular fluid being gaged. For high-pressure superheated steam either forged Monel metal or steel should be specified, with preference for the former material when high line pressures and total steam temperatures around 700 deg. F. will obtain. For other fluids where temperatures do not exceed 300 deg. F. a bronze or brass socket is commonly used. In any case where pipe covering is to be installed, sockets should be provided with a proper extension beyond the outer wall of the pipe line in accordance with the thickness of the pipe covering. Where possible, thermometer sockets are better located in a tee or elbow fitting as the active bulb length is then unlimited by the pipe diameter, and the turbulent flow condition due to the bend in pipe line should result in a more representative temperature indication at the thermometer.

Thermometer makers are prepared to furnish the scale bodies built at almost any angle from the bulb section. This feature should be employed to the user's advantage when purchasing thermometers, so that the unit when installed can be read with ease and accuracy.

Recording Thermometers

In general the foregoing remarks in connection with indicating thermometers can be applied to temperature recorders. In a majority of cases these recorders come under two classifications:

1. The so-called "class two" type in which the sensitive bulb is filled or partly filled with a volatile and low boiling point liquid. The recording attachment is actuated by the vapor pressure of this fluid at the temperature to be indicated.
2. The so-called "class three" type in which the sensitive bulb is filled with an inert gas expanding or contracting in accordance with the temperature variations, thereby actuating through pressure variations the recording attachment.

In either case a large sensitive bulb is necessary, more especially for the gas-filled thermometers, in order to give sufficient pressure to actuate the recording pen. It follows that in most instances the sensitive bulb and socket should be installed so that its necessary length will not be limited by the pipe diameter.

The so-called "class two" thermometers, or those depending upon the vapor pressure of a volatile liquid, are furnished with unevenly graduated charts so designed that the normal pressure range is enlarged, whereas the subnormal pressure range is suppressed. This is a useful feature which can be taken advantage of where applicable to working conditions. When this class of instrument is selected, the manufacturer should be advised of the amount of any elevational difference between the sensitive bulb and the recording device so that this can be taken into account when the instrument is being calibrated at the factory. Usually, the "class two" instrument is employed for temperatures between 50 deg. and about 400 deg. F. In general, the length of connecting tube is limited only by the size of the sensitive bulb, but ordinarily the limit is set at 200 or 300 feet.

For temperatures higher than can be handled by the "class two" thermometer, the "class three," or gas-filled type, is generally employed. This can be used for temperatures as high as 1,000 deg. F., and satisfactory results can be obtained with the connecting tubing 400 ft. or 500 ft. long. Where average temperatures of air or gas passing through a duct or boiler gas passage are required, the instrument-makers can provide a sensitive bulb long enough to extend completely across the duct or gas passage so that the resultant of the average temperatures can be transmitted to the recording element.

As in the case of recording pressure gage charts the instrument-makers can provide recording thermometers

equipped with inverted or reversed scale charts where their use may be indicated on account of the normal and maximum temperature variations.

Electric Thermometers and Pyrometers

The employment of electric resistance coils or thermocouples in connection with low-voltage potentiometers or galvanometers for measurement of temperatures has been a more recent development for power-plant service. In place of a gas- or liquid-filled thermometer bulb the socket inserted in the pipe line or apparatus is provided with a small resistance coil or thermocouple. This so-called "hot-end" is connected by an electric circuit to a properly calibrated millivoltmeter or galvanometer. Thus, the low-voltage currents produced at the hot end device are translated by suitably calibrated scales to indicate or record the corresponding fluid temperature.

These are especially applicable to measurement of temperatures above the range of ordinary thermometers, and even for the lower temperature ranges where indicating or recording thermometers are commonly used, they possess the advantage of employing standard electric wire connections in place of long capillary tubing. For this reason these instruments can be located at any required distance from the source of temperature being gaged and the errors due to temperature lag or capillary tube length adjustments obviously will be eliminated. Another desirable feature in connection with this type of temperature recorder or indicator is that any number of thermocouple elements can be wired to one central indicator or recorder, and by means of a selective switching device the several temperatures at remote points can be indicated or recorded at one central point or, if desired, can be recorded on a single chart.

Flow Meters

The types of flow meters most commonly used for power-plant service are those employing differential pressure produced either by venturi tubes or by orifice or nozzle plates inserted between pipe flanges; or by a standard or patented form of pitot tube inserted into the pipe. In any of these cases the fluid, when flowing through the orifice or tube, produces a pressure differential which is transmitted to the flow meter proper by pressure pipes connecting at the upstream and downstream sides of the device located in the pipe line. This differential pressure deflects a mercury column in the instrument, thereby moving a float or making electrical contacts or impulses in proportion to the flow rate of the fluid. Where the electrical type of instrument is employed, the contact or induction element in connection with which the mercury column functions, can be located at some point close to the accompanying device installed in the pipe line, and the indicating and recording instrument proper may be placed wherever desired on account of its being connected electrically to the differential pressure element.

Another type of flow meter employs a balanced beam on which closed vessels are suspended at each end. These vessels are partly filled with mercury and are connected by a small tube at their lower ends so that the mercury is equally distributed in the vessels at zero flow. The fluid pressures from the orifice device are connected to the upper ends of these vessels and thereby transfer through pressure differences a greater or less amount of mercury to the opposite vessel. Consequently, the beam movement is proportional to the fluid pressure differences, and this in turn is converted into a pen movement recording the equivalent flow rates. The simplicity of this device is an attractive feature.

In conjunction with the fluid flow recording and indicating devices provided with the mechanically operated flow meter, some of the manufacturers can furnish auxiliary attachments for recording or indicating the pressure or temperature of the fluid being measured or other correlated conditions. These various auxiliary attachments are designed so that these conditions may be recorded on the same chart with the fluid flow record.

Among the other flow meters sometimes used for certain phases of power-plant operation are included weir type or V-notch type liquid flow meters generally employed for measuring feed water or condensate under atmospheric or extremely low pressure conditions and also used to some extent for measurement of water blown down from the boiler mud drums.

Various types of disk or rotary displacement meters are selected for service in connection with liquid flow through small pipe lines where precise measurement is not required and where the quantities to be measured are in small enough amounts to allow the use of this type of metering device. These meters are also employed for measurement of heated or unheated fuel oil in power plants.

Gas Analysis Recorders

In the majority of cases some form of recorder for gaging the quality of the combustion gases leaving the boiler is considered essential. Usually, the instrument for this service consists of a CO_2 recorder of either the chemical absorption or the electrical conductivity type. Some manufacturers have anticipated the demand for a more complete examination of the products of combustion and have added to the device for determining the CO_2 content, an attachment to determine the amount of CO.

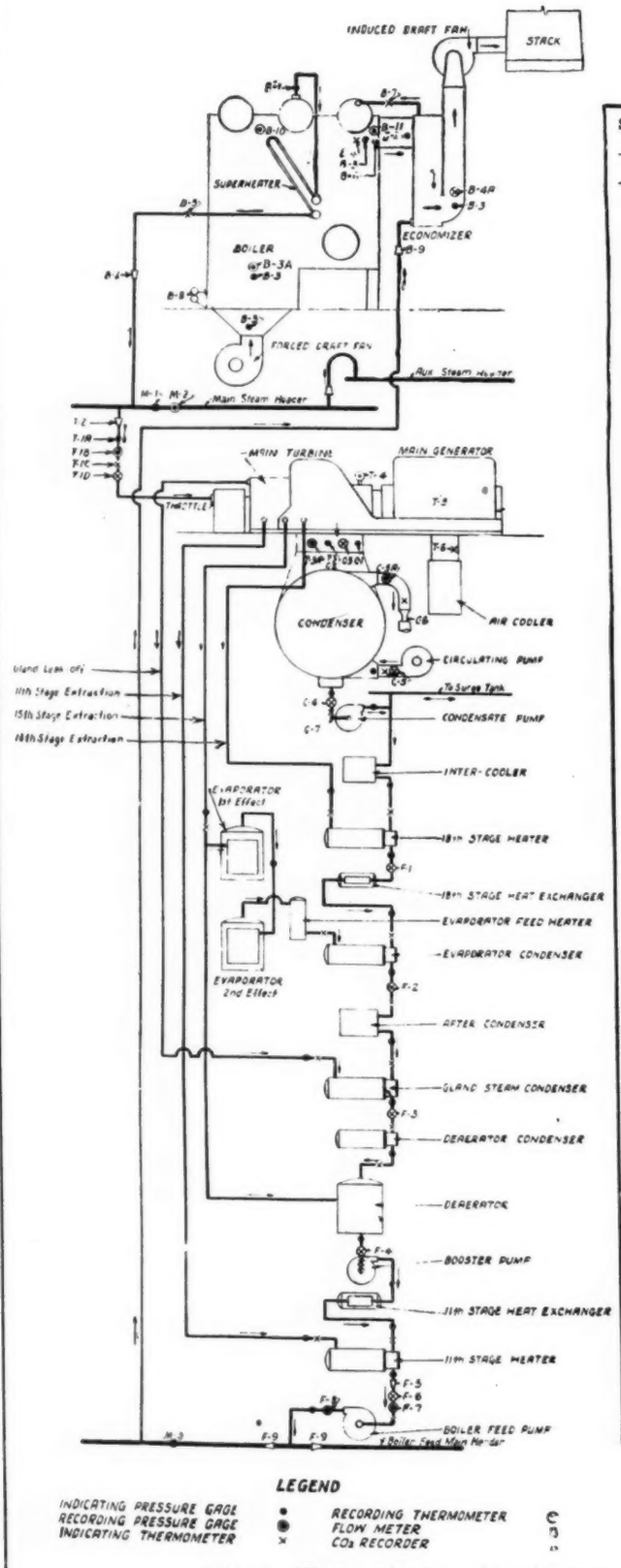
One manufacturer has developed a boiler meter now widely employed for determining indirectly the CO_2 content in the combustion gases. This instrument is provided with a so-called "air flow" recording pen that is actuated by the flow of the products of combustion through the boiler setting. This flow, under proper operating conditions, should vary directly as the rate of steam generated by the boiler. Accordingly, the records of the "steam flow" and the "air flow," combined to suitable scales on one chart, serve to indicate the correct relation of these two conditions at any rate of operation. This instrument necessarily must be calibrated when initially installed, against actual analyses of the stack gases for any one class of fuel. Thereafter, the relation of the steam-flow and air-flow chart records serves to indicate the degree of correctness of the boiler combustion operation.

It is essential, however, that the active elements of these gas-analysis instruments be installed at a point sufficiently close to the point of gas sampling to avoid an excessive time lag in recording the fluctuations of the gas quality.

Draft Gages

The need for this type of instrument is usually for application on boilers to measure the draft conditions at various points through the boiler setting and also to measure the available forced- or induced-draft pressures in the draft systems.

The inclined or vertical liquid-filled manometer, because of its simplicity and accuracy, is widely used.



Symbol No.	Service	Remarks
	Individual Boiler Panel	
B-1	Boiler Steam Pressure	12-in. Indicating Pressure Gage—Usually mounted separately on Boiler Front
B-2	Boiler Steam Flow	Indicating—Recording—Integrating Steam Flow Meter
B-3 & B-3A	Boiler Draft and Air Supply to Boiler Furnace	Indicating Draft Gages—Usually combined into one Multiple Gage Instrument
B-4 & B-4A	Stack Gas Temperature	Recording Thermometer—Single or Two Pen Recorder
B-5	Steam Temperature leaving Superheater	Indicating Thermometer—Superheater Outlet
B-6	Stack Gas Analysis	CO_2 or CO_2 + CO Recorder—Absorption or Electrical Type
B-7	Feed Water Temperature leaving Economizer	Indicating Thermometer—Water Outlet from Economizer
B-8	Stoker Feed Rate	Revolution Counter or Tachometer—Stoker Drive
B-9	Boiler Feed	Indicating—Recording—Integrating Water Flow Meter
B-10 & B-11	Air Flow	Connections if Steam—Flow Air-Flow Meter is used B-2 (Steam Flow) B-3A, B-10, B-11 (Fire Box Draft and Air Flow) B-4A (Flue Gas Temperature Recorder)
	Master Panel Boiler-Room	
M-1	Main Steam Header—Pressure	Master Pilot Gage—Large Dial, Suppressed Scale
M-2	Main Steam Header—Pressure	Recording Pressure Gage
M-3	Feed Water Main Header—Pressure	Indicating Pressure Gage—10 in. or 12 in. Dial
	Turbo-generator Gage Board	
T-1A	Steam to Turbine Throttle	Indicating Pressure Gage
T-1B	Steam to Turbine Throttle	Recording Pressure Gage
T-1C	Steam to Turbine Throttle	Indicating Thermometer
T-1D	Steam to Turbine Throttle	Recording Thermometer
T-2	Steam to Turbine Throttle	Indicating—Recording—Integrating Steam Flow Meter
T-3	Condenser Vacuum	Mercury Column Vacuum Gage—Suppressed Scale
T-3A	Condenser Vacuum	Recording Vacuum Gage
T-4	Turbine Speed	Indicating Tachometer or Frequency Indicator
T-5	Generator Load	Indicating Wattmeter
T-6	Air leaving Generator	Indicating Thermometer with High Temperature Alarm Contact
	Condenser Gage Board	
C-1	Condenser Vacuum	Indicating Vacuum Gage
C-2	Condenser Vacuum	Barometer—Mercury Column
C-3	Condenser Steam Temperature	Recording Thermometer
C-4	Hotwell Condensate Temperature	Recording Thermometer
C-5	Circulating Water Temperature—entering Condenser	Recording Thermometer—Single or Two-Pen
C-5A	Circulating Water Temperature—leaving Condenser	Recording Thermometer—Single or Two-Pen
C-6	Circulating Water Flow	Recording Water Flow Meter
C-7	Condenser Tube Leakage	Salinometer—Conductivity Recorder
	Boiler Feed Gage Board	
F-1	Condensate Temperature	Recording Thermometer
F-2	Condensate Temperature	Recording Thermometer
F-3	Condensate Temperature	Recording Thermometer
F-4	Condensate Temperature	Recording Thermometer
F-5	Condensate Flow from Unit	Recording Flow Meter
F-6	Boiler Feed Temperature	Recording Thermometer
F-7	Boiler Feed Pump Inlet	Recording Pressure Gage
F-8	Boiler Feed Pump Discharge	Recording Pressure Gage
F-9	Boiler Feed-Main Header	Indicating—Recording—Integrating Flow Meter or Meters

Fig. 4—Shows where various instruments should be connected into the system

Several manufacturers have developed multiple pointer gages which combine in one casing, the indicating pointers serving two, three or more locations where draft or air-pressure conditions are to be indicated. Each pointer is actuated by a diaphragm or by an oil-submerged float into which the pressure or suction to be gaged is piped. These instruments are in some cases provided with large internally illuminated scales, and owing to their easy legibility and compact design are desirable for individual boiler gage boards.

Tachometers and Revolution Counters

On boiler installations provided with automatic stokers a revolution counter or tachometer connected to the stoker drive is usually provided. This serves to gage the rate of fuel delivered and is occasionally used as a check upon other fuel-measuring equipment.

Where comparatively high rotative speeds are to be measured, the employment of an electrical or vibrating reed tachometer is provided. The latter type is commonly used in connection with turbo-generators.

Boards and Panels for Instruments

Panel boards for mounting instruments are usually of two types:

1. Boards of light weight and suitably reinforced steel plates properly finished for appearance and drilled to accommodate the instruments to be installed. These panels can be constructed easily and cheaply and are desirable where extremely large boards are required or where the first cost must be as low as possible.
2. Boards made from heavy marine-finish slate panels provided with beveled edges and drilled to accommodate the instruments. For this type of board the instruments are usually provided with back connections.

Owing to the size limitations of the quarried material for these panels, the gage board is built up of separate panels usually not exceeding 4 ft. for their greatest dimension. It is possible to obtain larger single pieces of slate, but the delay and expense attendant upon these larger pieces renders their selection undesirable. For supporting the assembled slate panels the standard types of electrical switchboard supporting material are convenient. These consist of standard steel pipe, U-bolts and clamp fittings for attaching the slate panels to the supports.

Typical Installation

Fig. 4 is a line diagram showing the arrangement of the principal mechanical equipment installed in a typical modern power station employing high steam pressure and temperature and having the usual equipment necessary for reheating the condensate from main turbine stage bleeding. The various types of instruments are denoted by symbols placed on the equipment or on the pipe lines connected thereto. To the right of the line diagram the instruments used on the more important gage boards are grouped and described more in detail.

Naturally, the equipment on each board differs with the conditions peculiar to the individual installation and on account of the location of the board with respect to the equipment. For example, the instruments indicated on the turbine generator gage board may be located in some stations on the condenser gage board, or vice versa. Similarly, the boiler-feed gage board which, on this illustration, includes recording thermometers for measurement of condensate temperature, may be placed in the boiler room. Then the various recording thermometers for measurement of condensate temperatures may be placed either on the condenser gage board or on a separate panel provided solely for condensate heating equipment.

In other cases it may be preferable to install certain recording or indicating gages on small panels fastened directly to the equipment served by them rather than placing them on a larger and more general panel board located some distance from the equipment.

It follows that the arrangement of the various instruments and the various panel boards selected, becomes in the final analysis, a matter of personal opinion dictated by the best judgment of those in charge of this work.

Individual Boiler Panel

Fig. 1 shows a multipointer indicating gage provided with the following:

1 Forced-draft fan pressure gage
1 Windbox pressure gage
1 Furnace draft gage
1 Inlet economizer draft gage
1 Outlet economizer draft gage
1 Fuel-gas header pressure gage
1 Fuel-oil header pressure gage
1 Water from economizer temperature gage
1 Boiler meter having 1 steam flow indicating, recording and totalizing meter, 1 combustion or so-called "air flow" recorder, 1 recording thermometer for stack gas entering economizer, 1 recording thermometer for stack gas leaving economizer, and 1 duplex CO_2 and CO recorder for stack gases.

The lowest section of this board is provided with starting, stopping and speed-regulating buttons for controlling the draft fan motors and also automatic control solenoids for shutting off the fuel delivered to boilers through suitable relay valves.

Each condenser at this plant is served by two circulating water and two condensate pumps, the circulating water being discharged from the condenser through two outlet lines. Accordingly, one board, as shown in Fig. 2, is provided for each condenser. On each board the following instruments are mounted:

2 Circulating water inlet pressure gages
2 Circulating water outlet pressure gages
2 Condensate pump discharge pressure gages
2 Two-pen recording thermometers showing temperature of steam entering and circulating water leaving each side of condenser
1 Two-pen recording thermometer showing temperature of circulating water entering and condensate leaving condenser
1 Indicating vacuum gage
2 Indicating and recording meters for flow of circulating water from each side of condenser.

In addition to the instruments named, the condenser equipment is provided with a recording salinometer for detecting possible condenser tube leakage. A recording vacuum gage and also a standard mercury-column indicating vacuum gage are located on each turbine gage board rather than being placed on the condenser gage boards.

At this plant the condensate from each main unit passes through the various stage heaters and deaërators installed with each unit. These condensates are combined at the suction header of the boiler-feed pumps and from there on are delivered through a common boiler-feed piping system to the boilers. The gage board shown in Fig. 3 is located adjacent to the boiler-feed pumps, these being common to both main condensate systems. On the two left-hand panels are mounted the instruments for one unit, and duplicates are mounted on the two right-hand panels for the other

unit. Hence, the following description applies to one-half of the total instruments shown in Fig. 4:

2 Indicating pressure gages—boiler feed pump discharge
1 Electrical type indicating and recording condensate flow meter (measuring total flow of condensate from one unit to suction of boiler-feed pump).
1 Recording pressure gage—condensate after deaërator booster pump.
1 Recording pressure gage—boiler-feed main header (auxiliary header gage is on the adjacent section of board).
1 Recording thermometer—condensate after 18th stage heater.
1 Recording thermometer—condensate after evaporator condenser.
1 Two-pen recording thermometer—condensate entering and leaving deaërator
1 Recording thermometer—condensate after 11th stage heater

The foregoing illustrations and descriptions of typical gage-board installations, together with the diagram arrangement of instruments shown in Fig. 4, will serve to show in a general way the requirements for a modern power plant. No hard and set rules can be cited for guidance in selecting this equipment, as the scope of this work will vary for each particular plant. Care should be taken, however, not only that all essential instruments are installed, but that non-essential ones are omitted. Unnecessary instruments produce records that are not vital to the operation and by adding to the data obtained, tend to confuse the interpretation of the useful records.

Tendencies in Power-Plant Design

By A. A. Potter and J. W. Geiger*

An EXAMINATION of the design characteristics of large power plants reveals the following interesting facts:

Combustion Chambers: The volumes of the combustion chambers vary from 0.75 cu.ft. per 10 sq.ft. of boiler-heating surface for a plant of 57,000 kw. capacity installed in 1901, to 5.23 cu.ft. for another plant of 40,000 kw. capacity installed in 1920. This ratio is not dependent upon the size or upon the capacity of the plant, but upon the year in which it was erected. The general tendency in recent years seems to be for larger volumes of combustion chambers. Thus a plant of 125,000 kw. capacity installed in 1891 had 1.17 cu.ft. of combustion space per 10 sq.ft. of boiler-heating surface; one of 122,000 kw. installed in 1904 had a volume of 1.69 cu.ft.; one of 110,000 kw., in 1914, 2.2 cu.ft.; one of 100,000 kw. in 1918, 2.81 cu.ft.; one of 40,000 kw., in 1920, 3.28 cu.ft., and one of 40,000 kw. in 1921, 4.58 cu.ft.

Height of Combustion Chamber: The height in feet depends on the type of boiler, method of baffling and fuel used. This varies from three feet for a plant of 57,000 kw. capacity equipped with single-ended Stirling-type boilers, to 29 ft. for another plant of 180,000 kw. capacity equipped with double-ended boilers of the same type. When the data from this examination are arranged chronologically, it may be readily seen that there is a general trend toward greater height of combustion chambers. For example, with horizontal cross-drum boilers a plant of 120,000 kw. capacity, installed in 1904, had a height of combustion chamber of only 4 ft.; one of 125,000 kw., installed in 1912, had a height of combustion chamber of 8 ft.; one of 100,000 kw., installed in 1918, had a combustion-chamber height of 10 ft., and one of 60,000 kw., in 1920, had a height of 16 feet.

Boiler-Heating Surface: The boiler-heating surface in square feet per kilowatt capacity of the plant varies from 1.32 for a plant of 95,000 kw. to 4.1 for another plant of 47,000 kw. In this case there seems to be no direct connection between the square feet of heating surface per kilowatt and the year in which the plant was installed, or any definite relation to the size or capacity of the plant. The average square feet of heating surface per kilowatt-hour capacity, of plants erected between 1901 and 1922, is about 2.50.

Superheater Surface: The superheater surface in square feet per square foot of boiler-heating surface is next to be considered. The minimum value is 0.0548 sq.ft. for a plant of 57,000 kw. capacity, as compared to a maximum value of 0.45 for another plant of 40,000 kw. capacity. Date of erection and capacity seem to have no direct bearing on this ratio, and the average is about 0.21 sq.ft. of superheater surface per square foot of boiler-heating surface.

Economizer Surface: The economizer heating surface per kilowatt capacity of the plant varies from 0.5 for a plant of 60,000 kw. capacity to 2.0 for another plant of 47,000 kw. The average economizer heating surface per kilowatt is about 1.13 square feet.

Power To Drive Auxiliaries: The horsepower required per kilowatt of plant capacity for driving induced-draft fans varies from 0.0073 for a plant of 60,000 kw. to 0.042 per kw. for a station of 50,000 kw. The average is about 0.0203.

The horsepower per kilowatt of plant capacity to drive the forced-draft fans varies from 0.005 for two plants, one of 60,000 kw. and one of 40,000 kw. capacity, to 0.035 for another plant of 50,000 kw. The average value is 0.0169 hp. per kilowatt capacity.

The horsepower per kilowatt to drive the condenser pumps varies from 0.017 for a plant of 128,000 kw. to 0.057 for another of 50,000 kw. The average power required to drive condenser pumps is about 0.03164 hp. per kilowatt capacity of plant.

Capacity of Auxiliaries: The capacities of boiler-feed pumps expressed in gallons per minute per kilowatt capacity of plant, vary from 0.0334 for a plant of 125,800 kw. to 0.102 for two other plants, one of 47,000 kw. and one of 27,500 kw. The average value is 0.06345 gal. per min. per kilowatt.

The capacity of the coal-handling equipment shows quite a large variation, varying from 1 ton per hour per 1,000 kw. capacity for a plant of 151,000 kw. to 16 tons per hour for another plant of 50,000 kw. However, the general tendency is well shown by the average figure of about 4.25 tons.

The principal benefit afforded by ball and roller bearings arises from the fact that lubricant is effectively retained and does not work into the commutator and windings of the motor. Oil leakage from bearings is pronounced responsible for more than half the motor failures. Incidentally, the absence of oil drip may be of considerable import where cleanliness is necessary. They require less attention than other types and have been known to survive in spite of prolonged neglect.

*Members of the Engineering Staff, Purdue University.

High Efficiency in 1,000-Kw. to 6,000-Kw. Steam Turbines

By SANFORD A. MOSS*

THE gross cost of the power produced by a turbine is the sum of three items: The interest, depreciation and other fixed charge percentages of the first cost; the cost of maintenance; and the cost of steam. The gross cost of power, therefore, often has been decreased by using a turbine with increased efficiency. Many accounts have been given of high efficiency with large steam turbines. Steam turbines with medium output, 1,000 to 6,000 kw., are much more common in point of numbers than the large steam turbines, yet little has been said about their increasing efficiency. It is often supposed that high efficiency is not sought in plants using turbines of such medium size. This is not true, however, and many such plants are using turbines of high efficiency for low power cost.

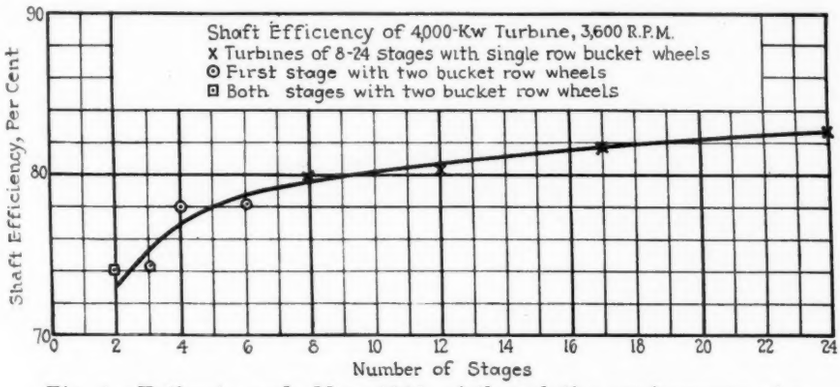


Fig. 1—Estimate made May, 1913, of the relative performance of a turbine with varying number of stages (curve reproduced from the original)

With turbines of less than 1,000 kw. high efficiency is not so important as first cost, simplicity, operation by available personnel and cost of maintenance. In the case of large turbines high efficiency is of paramount importance, and while the designer cannot always lay out the most efficient turbine regardless of cost, he is not greatly hampered by questions of expense and can devote his attention primarily to efficiency. In this region, from about 1,000 to 6,000 kw., the designer has the double problem of approaching the high efficiency of the large turbines while also maintaining features that restrict the cost to that characteristic of the small ones.

The problem has been solved by a particular way of subdividing an impulse turbine into stages. There has been a great variety of ways in which this subdivision has been accomplished. The original impulse turbine of Pelton and DeLaval had but a single stage, and Curtis patented in 1896 and 1897 the principle of "subdivision" by the use of a number of stages, each with either a single bucket row or with two or more bucket rows. The first Curtis turbines built by the General Electric Company had two or more bucket rows per stage, and hence this construction came to be associated with the name of Curtis. The original Curtis patents included, however, subdivision by use of a number of stages, each with a single bucket row per stage. During the development of the art resort was had to many combinations of constant and varying wheel diameters and numbers of bucket rows per stage.

The late Richard H. Rice, then chief engineer of the Lynn turbine department of the G. E. Co., exhibited in May, 1913, the curve, Fig. 1. This shows the estimated performance of turbines with a comparatively large number of stages designed according to the proposed principle. The values given were ideals that have since been approximated closely in practice. The curve shows that a turbine with medium output can be constructed with an efficiency approximating that of a large turbine. Since this first proposal in 1913, the principle has been used to an increasing extent.

The principle is the subdivision of a turbine of medium output into a comparatively large number of stages with diameters selected so as to give such a proportion of "fixed losses" as to provide a high efficiency in each stage. This results in a turbine that approaches "constant stage efficiency."

These fixed losses include rotation loss and leakage loss; they must be handled by mathematical formulas that cannot be given here. Application of this principle gives a turbine with rather small wheels in the high-pressure stages and with increase of diameter at a successively increasing rate up to the largest wheel commercially desirable at the low-pressure end.

There is thus a great change of diameter between the first and last stages, with a slow rate of change of diameter at the high-pressure end and a rapid rate at the low-pressure end, giving a sort of parabolic variation. Such variation introduces some problems of design of nozzle approach which have been successfully solved.

Fig. 4 is a view of the rotor of an extreme example with 40 stages and shows the character of the variation of wheel diameter that results from the use of this principle. The small diameter of the stages at the high-pressure end results, of course, in a very low velocity of both buckets and steam in this region.

This principle is primarily suited to the proportion of fixed losses that occur in turbines of medium output. Turbines of small size cannot be built with a sufficient number of stages to give high efficiency, because of cost reasons. Turbines of large size have

*Research Engineer, General Electric Co., Lynn, Mass.

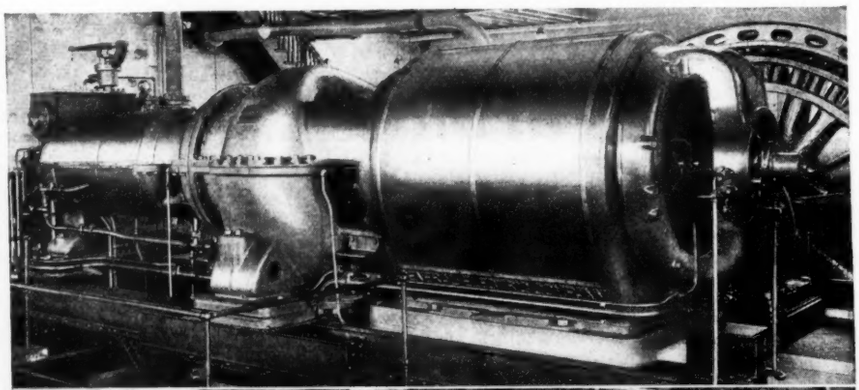


Fig. 2—Nineteen-stage, 1,000-kw. turbine at the Gloucester Electric Co.

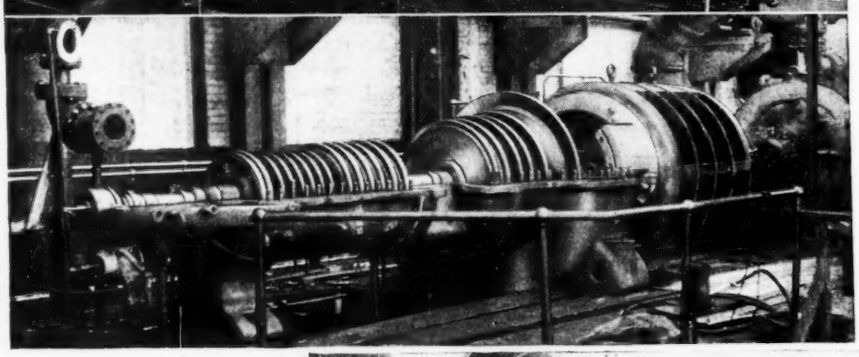


Fig. 3—Showing bearing between wheel casings of unit above

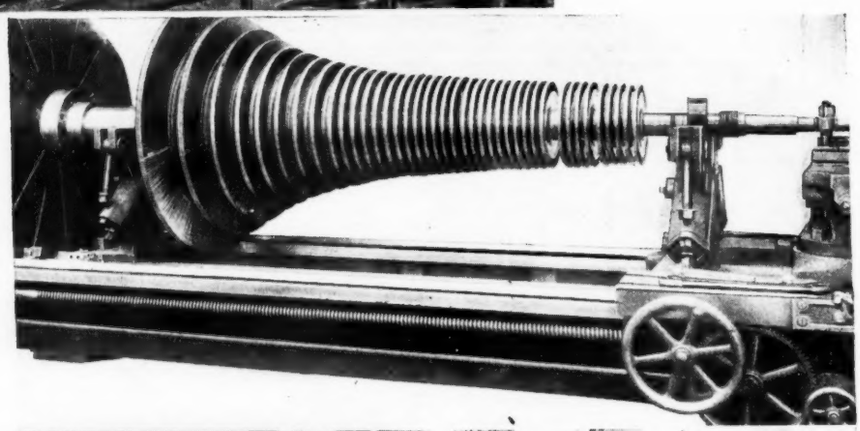


Fig. 4—Rotor for single wheel casing of 40-stage turbine

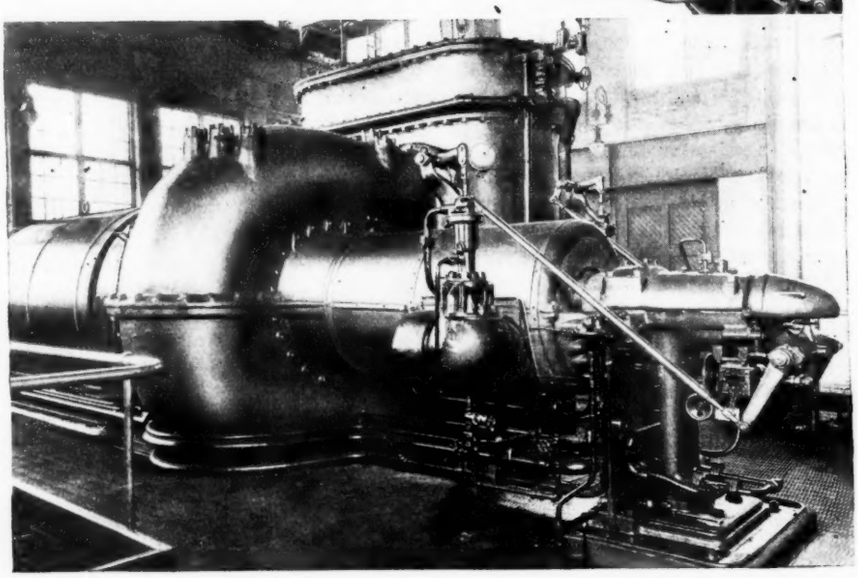


Fig. 5 — Forty-stage 3,000-kw. turbine at the power house of the Lynn factory, General Electric Co.

such a small proportion of fixed losses that they do not require so many high-pressure stages.

This principle of "constant stage efficiency" is an ideal, and actual turbines depart from it to some extent. In the extreme case of the 40-stage turbine the principle is adhered to quite closely. Questions of first cost prohibit so great a number of stages in usual cases, however, and then the principle is adhered to as closely as possible. In some instances a departure that uses a two-bucket-row wheel in the first stage is desirable.

When the curve of Fig. 1 was first shown in 1913, the idea of a 4,000-kw. turbine with 18 to 24 stages was treated with some derision. It was demonstrated, however, that the first cost of an increased number of stages would be more than offset by the increase of efficiency that would be obtained as compared with the two- to five-stage turbines then prevalent.

The first turbine based on these principles was shipped by the General Electric Co. in 1916, to a public-service corporation in Michigan, where it is still in operation. This unit was a 1,000-kw. turbo-generator with a 19-stage turbine arranged for 150 lb. per sq.in. initial pressure. So far as is known, this has a greater number of stages than any impulse turbine before made. It also had a higher efficiency than any previous 1,000-kw. unit.

Shortly thereafter a second turbine was shipped to an electric company in Massachusetts. This installation is shown in Fig. 2. A second 1,500-kw. unit was later installed in the same plant. The interior of this turbine is similar to that of the 1,000-kw. unit shown in Fig. 3. In the first few machines the wheels were separated into two groups, with a bearing between. Later, turbines were shipped that were designed without this middle bearing.

The results obtained from this group of machines were encouraging, and many turbines of the same general type have been shipped since. An advanced example of the application of the principle is the 40-stage 3,000-kw. type. Fig. 5 shows one of these installed. Fig. 4 shows the rotor and Fig. 6 the sectional assembly of this machine.

Any combination of commercial requirements for turbines of medium output could be met by some one or other of the types of machines referred to. For cases where first cost is the paramount consideration, two- to five-stage turbines are used, with one, two or more stages having two-row wheels of comparatively large diameter. Where high efficiency is the paramount consideration, 30- to 40-stage turbines are available when desired.

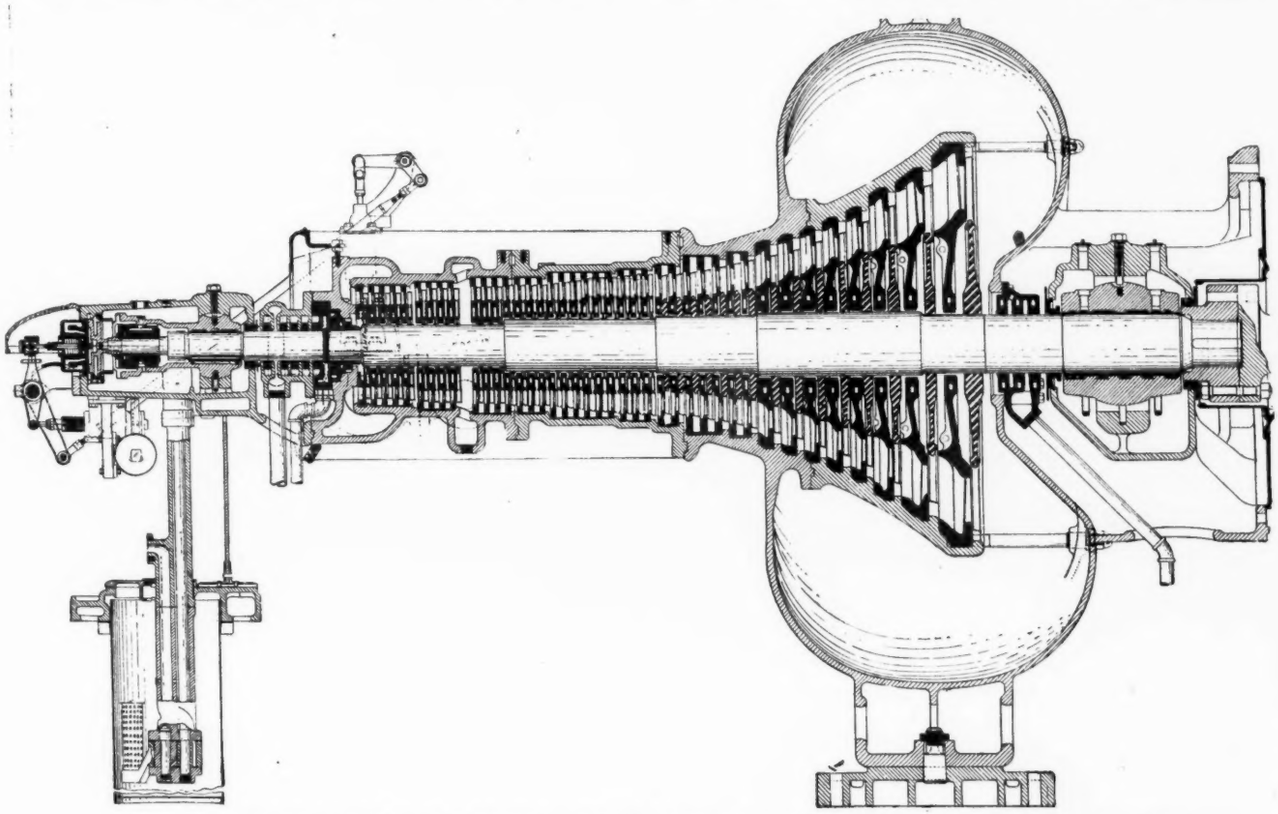
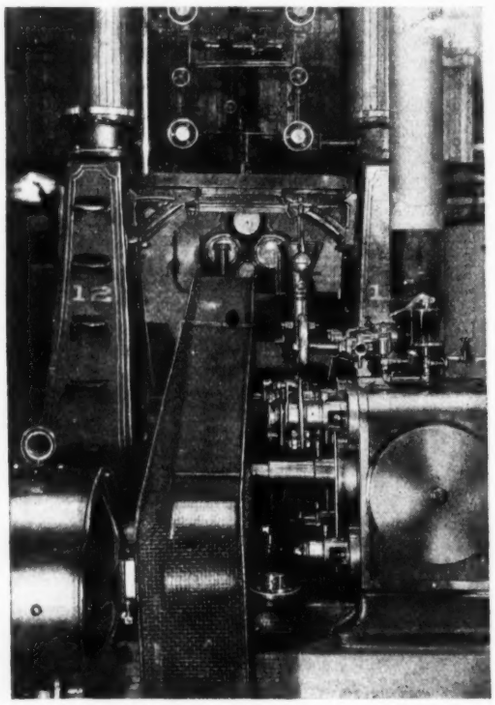


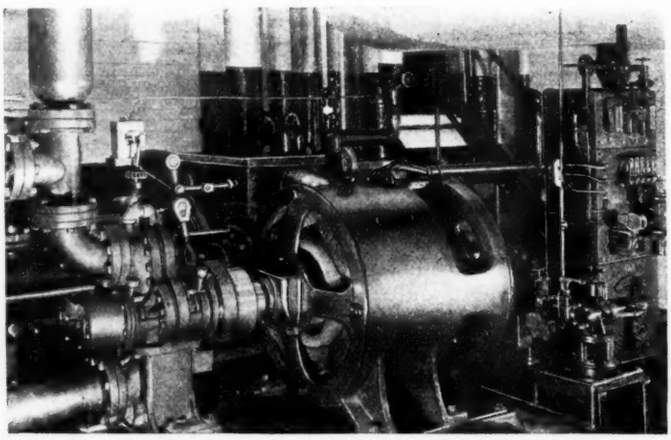
Fig. 6—Sectional assembly of a 40-stage, 3,000-kw. turbine with single continuous wheel casing

In practice, a commercial compromise must be made between highest efficiency and low first cost, giving an intermediate number of stages, best suited to the steam conditions and other requirements of the particular case. Turbines with from 10 to 15 stages meet requirements of the highest commercial efficiency.

An interesting corroboration of the principles of turbine design here mentioned is the recent use in Europe (Brunner High-Pressure Turbine, *Power*, p. 498, Sept. 23, 1924) of a comparatively large number of small high-pressure wheels for non-condensing turbines exhausting at high back pressure with the use of the low bucket and steam velocities already mentioned. The problem in this case is exactly that of the high-pressure end of the "constant stage efficiency" turbine referred to. The solution that has been worked out abroad closely resembles in design and efficiency the high-pressure ends of the constant-stage efficiency turbines proposed by Mr. Rice in 1913.

Below—Valve gear of Corliss cylinder driving ammonia compressor was disconnected and its connecting rod removed. Motor drives mainshaft by belt kept tight by idler swung from Corliss wristplate stud



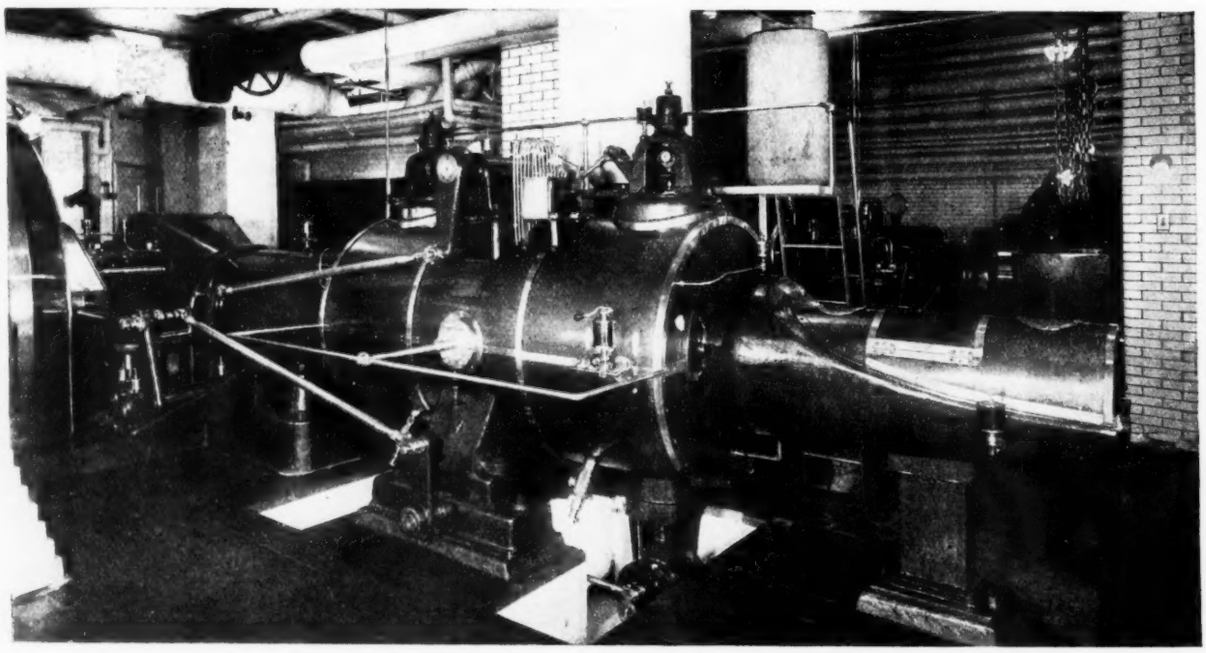


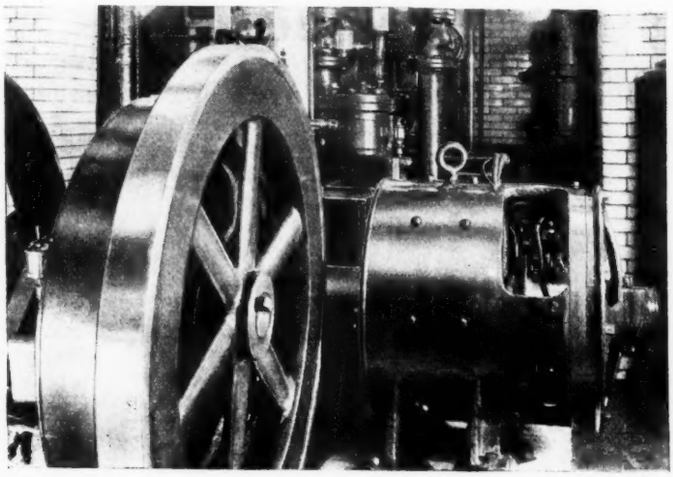
Above—Twin of duplex service pump in background was replaced by this motor-driven single-stage rotary pump operating against a pressure of 300 lb.

Ingenuity Saves Fuel in Office Building

The pictures on these two pages tell a remarkable story of fuel saving by the ingenious revamping of prime movers and auxiliaries in an important office building in downtown New York. The heart of the problem was the reduction of exhaust steam to the point where there would be no excess above heating requirements. This was accomplished by replacing a counterflow cylinder with a unaflow on one of the main units, to work in conjunction with compound engines, and by electrifying half of the auxiliaries. Great ingenuity was shown in electrifying various types of auxiliaries at a minimum cost. Where units were in duplicate, only one was changed to electric drive. As a result of these changes the auxiliary steam consumption has been cut 52 per cent, while the 26 per cent additional electrical load has increased the steam and fuel to the main units only 0.4 per cent.

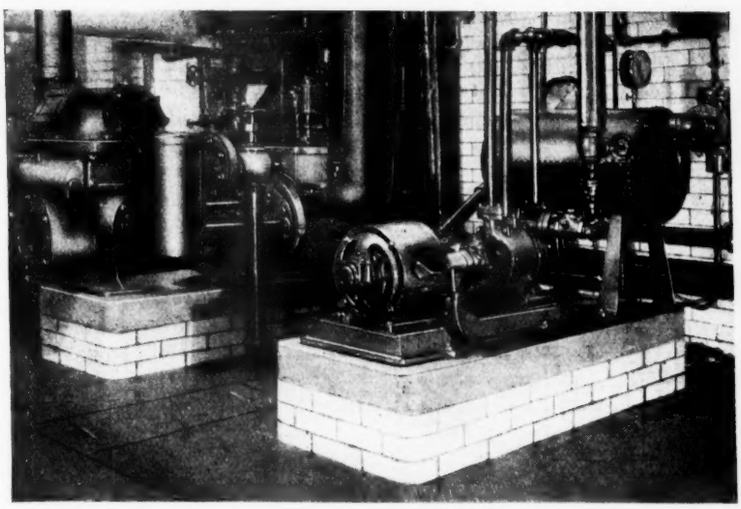
Below—On one 300-kw. main unit, Corliss cylinder was replaced by unaflow cylinder to save steam



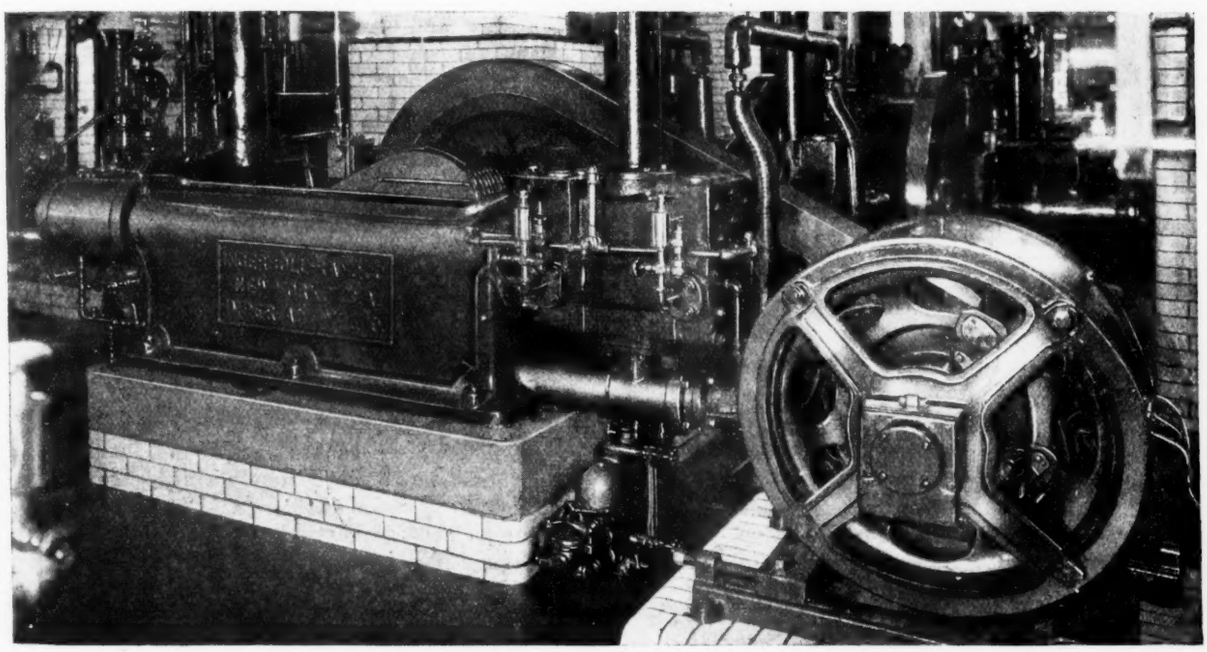


Left—Air pump for vacuum cleaning. Motor pinion drives spur gear mounted inside flywheel on main shaft. Piston was removed from tandem steam cylinder between crank and air cylinder. The duplicate vacuum pump retains the steam drive

Right—One vacuum drip pump was replaced by this electrically driven pump. Old unit in background



Below—Steam pistons were removed from rods on one two-stage air compressor, which was then motor driven through chain and sprocket. Steam drive retained on duplicate compressor



Protection of Electric Generators

Limiting Damage in Case of Failure in the Machine's Windings—Direct-Current Generators in Parallel—Differential Relay and Reverse-Power Relays on Alternating-Current Generators—Uses of Reactors and Lightning Arresters

BY C. R. CHACE
Engineering and Inspection Division, The Travelers Insurance Company

ONE of the problems of the designer of large power plants is to secure adequate protection for generating equipment. This problem becomes more important with the use of large units and more difficult under the modern conditions of high generator voltages, large transmission networks, tremendous capacities of prime movers and the necessity for maintaining uninterrupted service.

Failures of large units are in many cases due, in a large measure, to little or no protection of the machine. Often the failure of one coil in a generator will cause complete destruction of the entire winding, on account of the machine's not being promptly cut off the line, its field killed and the prime mover shut down. Sometimes the failure of an oil switch, trouble on the bus structure or in the switchroom will burn out a generator because an operator cannot or does not act quickly enough to save the machine. Automatic protection of all generators is necessary if these troubles are to be minimized.

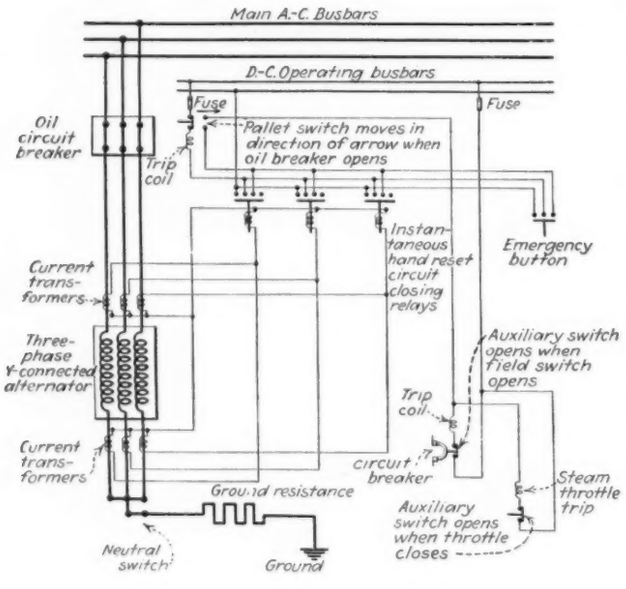


Fig. 1—Diagram of connections for differential-relay protection of alternating-current generators

Methods of protecting direct-current machines are practically standardized in modern power-plant practice. Circuit breakers with overload trip coils or overload relays are used on all feeders and between each generator and the bus to provide protection against short-circuits, grounds, overloading, etc. These devices do not always function properly owing to their not being properly maintained, set too high and in some plants short-circuited or otherwise intentionally rendered inoperative.

There are in a surprising number of power plants, particularly industrial plants, operating engineers who will purposely set a relay so high that it offers practically no protection to the machine. This is to keep the breaker from opening on sudden load peaks. Relays of the definite- or inverse-time-element type are designed to take care of the momentary swings in load and sustained overloads should not be carried on any generator. The engineer who will deliberately overset a relay or fuse a machine beyond its safe capacity is in the same class with the man who hangs grate bars on a boiler safety valve.

Direct-current generators paralleled with other machines or sources of supply, which will reach a dangerous overspeed or will injure their prime movers by becoming motorized, should have their circuit breakers fitted with reverse-current relays.

Generators that feed overhead lines with any considerable outside exposure should be protected against line surges and lightning disturbances by an efficient and properly grounded set of lightning arresters.

The protection of alternators, particularly those in large central stations where uninterrupted service is of primary importance, is a difficult problem. In the early days of alternating-current machines it was the practice to protect every machine with a relay or circuit breaker of some kind. Later, the pendulum swung the other way and for a number of years alternating-current generators were operated with practically no protection. Today the pendulum is swinging back again and the protection of alternators is becoming popular with power-plant designers. The idea that an alternator needs no protection still remains in the mind of many engineers, although it is a fallacy. It is true that the alternating-current generator is better able to withstand serious overloads, short-circuits, grounds, etc., than the direct-current unit, since there is no commutator to give trouble and the reactance of the machine's windings in many units is sufficiently high to keep the current within reasonable limits when a short-circuit occurs.

PROTECTING SMALL ALTERNATORS

Small alternators such as are found in many industrial plants should have the machine circuit breaker or oil switch provided with a series or transformer trip or overload relay, preferably of the time-element type, set to open the breaker when the safe limit of the machine's capacity has been reached. These machines are often of low internal reactance and may be burned out or be mechanically damaged by a sustained excessive overload or short-circuit. Furthermore, with the low voltages carried in these plants, bus structures

behind the switchboard are usually of open construction and are subject to short-circuits. In addition to this a switchboard operator is not usually present to cut the machine off the line in case of sustained overloading or other trouble.

There are many industrial plants that are sufficiently large to be considered in the class of central stations. Other industries have process work of such nature that any interruption in power supply would result seriously. In these plants, as well as in central stations, continuity of service is of primary importance and operating engineers object to relays that will cut a generator off the bus unless failure is certain to occur or actually does occur. Alternators in plants of this kind are often connected solidly to the bus bars through a manually

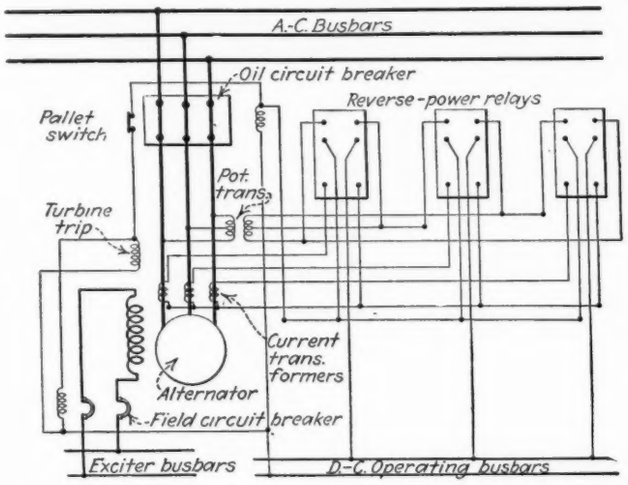


Fig. 2—Diagram of connection for reverse-power relay protection of alternating-current generators

operated oil switch, and the operators are depended upon to take the machine out of service in case of trouble that threatens its safety.

Use of Differential Relays

The most popular form of protection for large alternators is that known as differential or balanced relay, shown in Fig. 1. This type does not protect the machine against external trouble such as short-circuits, sustained heavy overloads, etc., but is effective in case of a short-circuit or insulation failure inside the machine. It is possible to install this form of relay protection only in star-connected alternators where the three leads that join to form the neutral point are brought outside the winding.

The principle upon which these relays operate is as follows: Six current transformers of equal ratio are installed, one on each lead of the alternator as in Fig. 1. The two transformers in the leads of each winding are connected in series, and this forms a closed circuit, with a relay coil connected across the leads between the transformers, as shown in the figure. As long as the current is balanced in the two transformers in each winding, such as is the case under normal operating conditions, current flows in the transformer windings only.

If a fault occurs in the generator winding, the current flow from the transformers on the affected leg is unbalanced. This causes a flow of current in the relay coil sufficient to cause that relay to close its contacts and trip out the circuit breaker. When the breaker opens, a pallet switch attached to it closes the circuit through two trip coils, one on the generator-field circuit breaker and the other on the turbine throttle, thus killing the field and shutting down the prime mover. These relays may be and sometimes are arranged to do other things such as shutting down the motor on the ventilating fan to prevent any fire in the winding from being fanned by the air current. In one station the relay in operating releases a weighted spear head which, in falling, punctures a thin copper disk releasing a charge of CO_2 under pressure which fills the generator casing and smothers any fire that might start.

There are some generators, particularly delta-connected machines, which cannot, by reason of their construction, be protected in the manner just described. Reverse-power relays are sometimes used to protect these machines, as shown in Fig. 2, by connecting them between the machine and the bus. These relays will protect a generator by preventing the current from other units feeding into it in case a fault occurs in its windings. These relays may also be connected to kill the field and cut the steam out of the turbine as well as to disconnect the damaged machine from the bus.

Current-limiting reactors are widely used as a protective device for alternating-current generators. Their reactance added to the internal reactance of the unit limits the current flow in case of short-circuit, ground or other disturbance to a safe value and greatly reduces the duty imposed on circuit breakers when opening under abnormal conditions.

Installation of Reactors

Reactors may be installed between the generator and bus where the machine has a low internal reactance. This is not the most satisfactory way of installing them under ordinary conditions, however, as the efficiency of the unit is reduced by the losses in the reactor. They are commonly installed between sections of the busbars, in which case one generator is connected to a section and reactors installed between the sections as well as on each feeder. The feeder reactors limit the flow of current into a feeder in case of trouble and reduce the duty on the feeder circuit breaker. The bus-section reactors prevent the exchange of large currents between sections, and the feeding of excessive current into a bus failure or failure of the winding in one machine. The use of differential protection on each alternator in conjunction with reactors constitutes one of the best forms of generator protection.

Temperature-actuated relays are sometimes used for the protection of large generators. These relays are usually installed with a thermal element embedded in each slot between the coils. They are sometimes arranged to ring an alarm bell in case the temperature of the winding rises beyond a safe limit. Infrequently, they are connected to trip out the machine. Thermal relays are also installed with the thermal elements embedded in the metal of the machine bearings to give warning of excessive bearing temperature.

Alternators are protected against surges, high-frequency oscillations and all disturbances of this nature by lightning arresters usually installed on the transmission lines and overhead feeders at the point of entry to the station, but sometimes connected to the leads for the individual machines. As an added measure of protection and to insure the operation of the lightning arresters, choke coils are installed between the arresters and the units to be protected.

Automatic Control for Forced-Draft Fans at Wabash River Station

By W. C. PLUMER
Industrial Control Engineering Department, General Electric Company

AT THE Wabash River steam plant of the Indiana Electric Corp., the forced draft for all the boilers is supplied from one main air duct, running the entire length of the station. The air for this duct is supplied at present from two fans, each of which is capable of delivering 187,500 cu.ft. of air per minute. Each fan is driven by an alternating-current three-phase 2,300-volt 16-pole commutator-type motor. These motors are designed for running on both Y and delta connection of the stator windings and have a speed range from 485 r.p.m. at 200 hp. to 285 r.p.m. at 20 hp. A motor-driven master switch is mounted above the commutator on each of the motors.

This arrangement of fans necessitated running all the motors at approximately the same speed to prevent one fan from blowing air through the other. This is taken care of electrically in the control of the motors, as these are not located sufficiently near to each other in the station to allow the use of any mechanical device. The selsyn motor is used in connection with the control of the motors for holding their speed constant.

Fig. 2 shows one section of the control board with the disconnecting switches, overload relays, ammeter, tie-in breaker, triple-pole double-throw switch and push-button station. Fig. 1 shows another section of the control board with the relay contactors for controlling hand and automatic operation of the motors. Fig. 3 shows a back view of Fig. 2 and the solenoid-operated main-line circuit breaker. Fig. 4 shows a back view of Fig. 1, together with the "Y" and delta contactors.

Starting the Fan Motors

With the brushes of the fan motor in the starting position to give the necessary starting torque, the motor is thrown on the line with the armature connected "Y" by pressing the start button. This closes the main-line oil circuit breaker and one of the triple-pole, oil-immersed magnetic contactors, which will be designed the "Y contactor." This cannot be done unless the brushes are in the starting position. The master switch on the motor has a segment which is in the closing circuit of the main-line breaker and makes circuit only in the starting position.

With the double-throw switch, Fig. 2, in the position marked "Hand," the speed of the fan motor can be changed by hand, using the "Fast" and "Slow" push buttons. If a higher speed is required, the "Fast" button is pressed, closing a contactor that will energize the pilot motor *P*, Fig. 6, on the master switch *S* and move the brushes in a direction opposite to the rotation of the motor until the highest speed on the "Y" connection is reached. This point is determined by segments on the master switch, shown in Fig. 5. At this point the "Y" contactor will open and the delta contactor will close, reconnecting the motor to the line with the armature-connected delta. At the same time relays on the control panel close and run the brushes back so as to give the same speed on the delta connection as the highest speed on the "Y" connection.

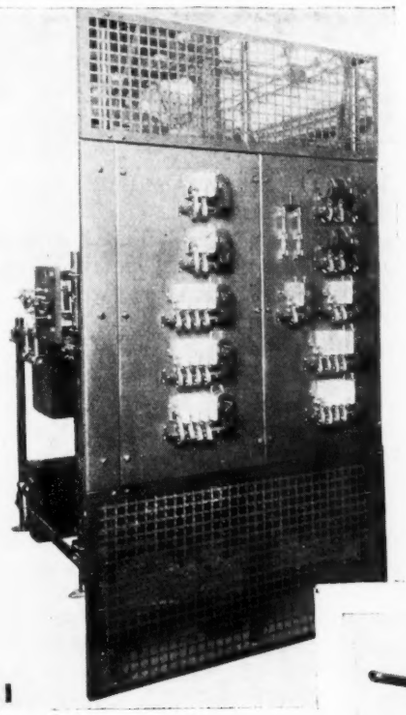
This transition is entirely automatic, and the operator has no control of the motor except to shut it down by pressing the "Stop" button, during this transition period. As soon as the brushes have moved to the correct position, the control is returned to the push buttons and further increases in speed are possible until the maximum speed of the motor is reached, which is determined by the master switch. Decreases in speed are accomplished in the same manner, using the "Slow" button, which so energizes the pilot motor as to run the brushes in the opposite direction. The brushes are moved to the lowest speed point on the delta connection, the motor is then reconnected and the brushes are run back automatically to give the same speed on the "Y" connection as the lowest delta speed.

Automatic Control of Motors

For automatic operation the triple-pole double-throw switch is placed in the "Automatic" position and the switch that supplies voltage to the rotors of the selsyn motors and generator is closed. The three-phase stators of the selsyn motors and the generator are connected in multiple, and the single-phase rotors are also connected in multiple with 110 volts alternating-current impressed on the circuit through contactors on the panel that are closed when the main motor is running. Each master switch has two selsyn motors—one for use when running on the "Y" connection and one when running on the delta. This is necessary as the brush position is not the same on the two connections.

With all switches closed for automatic operation and the motor running on the "Y" connection, the selsyn motor corresponding to this connection will take a position corresponding to the position of the selsyn generator. The position of the generator is determined by a regulator operating on steam pressure. If the regulator is calling for higher pressure, a contact finger fastened on the selsyn-motor shaft will make a circuit through segments on the master switch, causing the pilot motor to move the brushes and increase the speed of the main motor. The moving of the brushes also so moves the master-switch segment as to break the circuit made by the finger on the selsyn-motor shaft, which has taken a new position corresponding to the position of the selsyn generator, as soon as the brushes have been moved enough to give the required increase in speed. The transfer from "Y" to delta connection of the motor is done the same as on hand control.

If more than one of the fan motors are running on automatic control, they are all controlled from one pressure regulator, as the selsyn motors of each master switch are all in multiple with the generator. The ultimate capacity of this station calls for five forced-draft fan motors to be controlled from the one pressure regulator.



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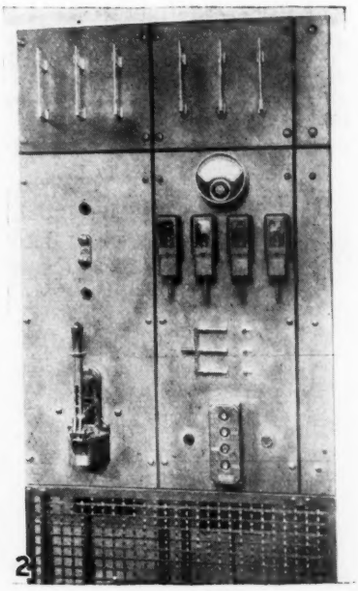

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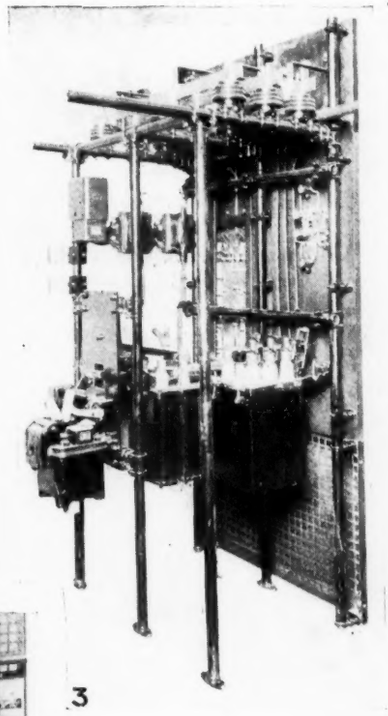

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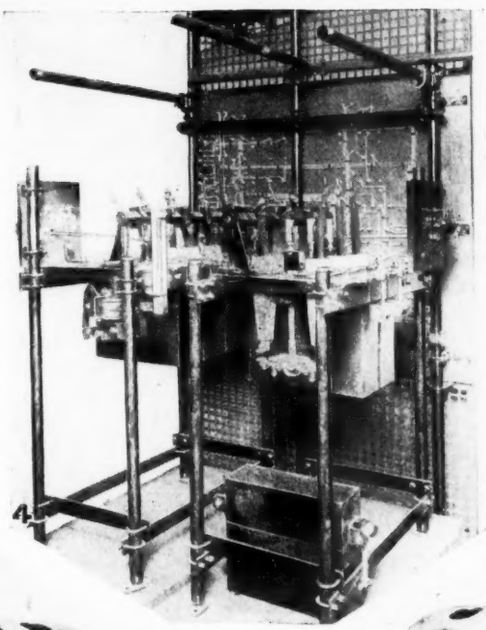
Figs. 1 and 4—Front and back views of section of control board with relay contactors for controlling hand and automatic operation of the commutator-type polyphase alternating-current motors, Figs. 5 and 6. Used to drive the forced-draft fans



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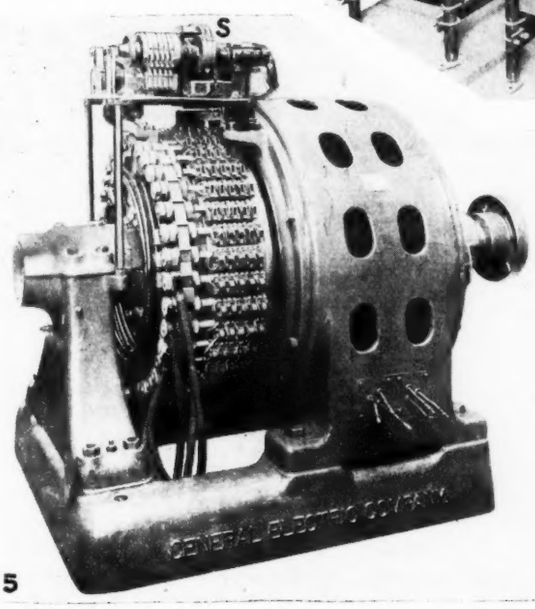
Figs. 2 and 3—Front and rear views of section of control board from which the operator may switch from hand to automatic operation of the fan motors, hand operation being exercised from the push-button station near the bottom of the right-hand panel, Fig. 2



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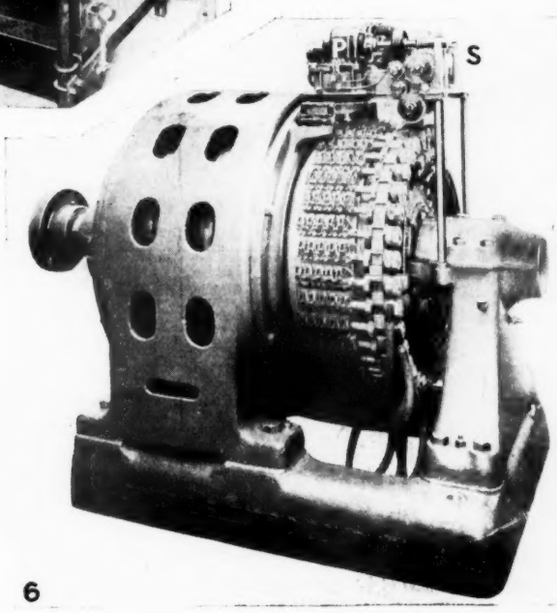

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The Application of Pulverized Fuel to the Industrial Plant

By W. EDWARD

THIS article endeavors to outline certain of the basic consideration surrounding the art of burning pulverized fuel, together with the correct procedure in making the installation proposal, that will supply an impartial basis for judgment of its merits.

THE consideration of this subject naturally divides into a comparison of the limitations and the potential advantages to indicate the practical middle course by which the prospective user may best gage the probabilities in actual operation.

The proposal itself centers upon gathering the essential data on which the manufacturer will base his recommendations and the resulting procedure in laying out the installation that will best approximate the indicated requirements.

Among the claims made for pulverized fuel are:

1. High operating efficiencies.
2. Successful burning of poor grades of coal.
3. Ability to raise pressure rapidly from a cold setting.
4. Close control of fluctuating loads.
5. High ratings are safe and economical.
6. Banking is unnecessary for temporary shutdown.
7. Elimination of fire-cleaning periods.
8. Comparative solution of the ash-handling problem.
9. Low cost of labor.
10. An installation that promotes cleanliness.

The qualifying limitations will show that:

1. Reasonably intelligent attention and continuous check and record of performance are essential to efficient operation.

2. The saving due to the possibility of burning poor grades of coal is only net after the saving at the coal pile has been discounted by the difference in efficiency that will result from the use of a better grade, other conditions being equal.

3. The sudden and intense heat from a pulverized-fuel burner, released inside a cold setting, can only result in high maintenance costs unless properly controlled.

4. For each given setting design there is a given range of permissible fluctuation which should be clearly defined by the installation engineers. Going beyond either limit will result in more loss than gain. If the upper limit is exceeded, the boiler maintenance will be materially increased. The too cold furnace, that will attend operation below the minimum, will fail to support complete combustion, as will at once be indicated by a sampler in the stack and an analysis of the ash.

5. High ratings are safe so long as watch is kept on performance and the recommended limit is not exceeded.

6. A pulverized-fuel-fired furnace will hold its heat for a considerable length of time after it is shut down, provided it is closed up. After this time the linings will be cold and must be so treated.

7. With the working parts of the pulverizers maintained to a point that will assure satisfactory pulverization (85 to 95 per cent through 200-mesh and 95 per cent through 100-mesh) with the burners set to take advantage of the maximum distance for flame travel and the velocity of the incoming coal and air held back of the point of impingement inside the combustion space, with the recommended limits of operation not exceeded and using the coal on which the installation was based or a better grade, there will be no need to shut down to clean out.

8. The actual amount of ash formed is reduced by the proportion of combustible that is actually consumed. To the apparently small amount that gathers in the ashpit must be added the true balance which is carried into the passes of the boiler. A part of this amount will settle out of suspension into the horizontal passes and at the turns around baffles where means must be provided to keep it cleared away. The other portion, and it is usually the larger, of that which does not stop in the ashpit, passes up the stack with the escaping gases. This portion is a powder, so fine that it appears only as a slight haze at the top of the stack unless the setting is operating improperly.

9. One reasonably intelligent attendant with a pulverized-fuel installation can replace a number of hand firemen. One fireman, on the other hand, cannot operate the system unless the principles he used when shoveling coal are materially altered.

10. The boiler house can be kept as clean as the attendants wish it to be, since there is no excuse for any other condition.

These points and many others, with their limitations, are advantages that may be held in favor of the art, not forgetting the fact that many of them are as validly claimed for stokers. While this article does not intend to discuss the relative merits of the two systems, it should be said, in passing, that before decision is reached by the prospective user he should impartially weigh the one against the other, but only after each has been reduced to its net possibilities for realizing a return on his investment.

Details that will form a basis for judgment as to the correctness of a proposed installation may be gathered by considering the procedure and the points of design brought out while preparing the proposal.

The data that must be secured as the initial step may be listed as follows:

The conditions that surround and control the use of the steam, present and future, including the sustained maximums, temporary peaks and low limits; the fuel proposed and other fuels available; the physical layout of the plant; the financial limit decided upon; the possibilities as to futures for each of these points.

No real difficulties are presented in getting accurate answers to these questions except in the case of the first and last ones, for, unlike the central station, knowledge of these two items on the part of the industrial manager is generally limited.

The condition itself may be said to be one of the principal factors in the strength of the central station which is tending toward the elimination of the isolated power plant and the attendant loss to the industrial manager of the opportunity to effect power savings peculiar to his business.

On the other hand, a survey of existing conditions, by a competent engineer, will produce the data necessary to the proposal at an expense small compared with the opportunities that will be pointed out for saving

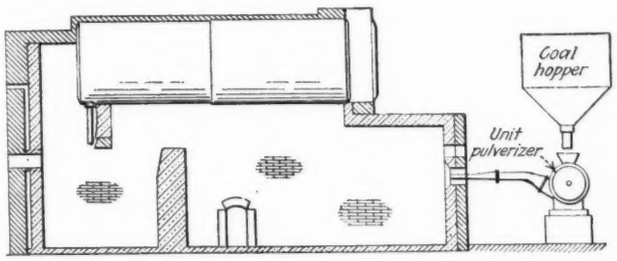


Fig. 1—Horizontal return-tubular boiler equipped with dutch oven for horizontal firing

costs regardless of whether pulverized fuel is installed or not. The fact that there are many such engineers who would gladly take a percentage of the saving they can direct, rather than a flat fee for their services, is an indication of what may be expected.

At this point comparison should be made between the storage and unit systems of preparing and delivering the pulverized fuel. In general, large installations are necessary to absorb the high first cost of the storage system. It provides a storage of prepared fuel between the pulverizers and the boiler which is a safeguard against the pulverizers being temporarily disabled, and also eliminates the problem involved in transporting coal to the burners with the air that is used for combustion. It will not handle satisfactorily wet coal without first drying it, and it requires more space than is generally available in the industrial plant.

The unit system compares favorably with stokers in first cost. It can be installed usually without material power-plant changes. It will handle wet coal, although this is a condition to be avoided since power input is approximately doubled for a given output when the moisture is between 12 and 14 per cent.

An indication of the trend of design is the fact that the manufacturers of storage systems are beginning to include unit equipments as a part of their line and that one maker of unit equipment recently closed an order for a number of unit machines that will supply fuel for a total of 120,000 sq.ft. of boiler-heating surface.

It should be stated, before going farther with the discussion, that there are two possible methods of firing which may be considered for many settings, vertical and horizontal. The relative merits are listed for comparison.

The flame travel in the vertical type is normally longer on account of its turning back on itself before it enters the tubes. This length is available without any expense to floor space in the plant. In no case should it be less than 15 ft. in a straight line from the burner, before the turn is made, at least until different means of completing combustion are discovered from those known today.

Poorer grades of coal may be burned.

The arrangement lends itself to the installation of the water screen, to a more flexible relation between radiating and heat-absorbing surface, and to the removal of ashes, particularly in battery setting.

The point of incoming fuel is normally a hot spot, and the direction is against the influence of the draft.

All these points result in the possibility of higher sustained ratings, greater fluctuations and increased efficiencies. The setting, however, is more expensive. The height required often involves excavation or alterations vertically to the boiler plant. The fuel delivery is more of a problem unless the machines are set on a balcony.

In the horizontal setting, even though it has the relative disadvantages, a dutch oven can be provided to increase the length of flame travel and the arch of this oven can be arranged to form an ignition arch.

The design lends itself more economically to change-over from existing settings, and the results that can be obtained will in many cases be efficient enough not to warrant the difference in cost for the more generally accepted design. In fact, there are many such settings giving satisfactory service under many varying conditions. The comparison in any case must be carefully made before decision is rendered.

The following sequence of steps is taken to make a unit-system layout and proposal of the vertically fired type.

1. Calculate coal required for specified power output. Assume for purposes of example:

Range of rating, 100 to 200 per cent; maximum boiler output required, 34,500,000 B.t.u.; base efficiency for calculations at 75 per cent; heat value of coal as fired, 13,000 B.t.u.

Then the coal required per hour $= \frac{34{,}500{,}000}{13{,}000 \times 0.75}$

or approximately 3,550 lb.

2. Calculate furnace volume required. Allow (based

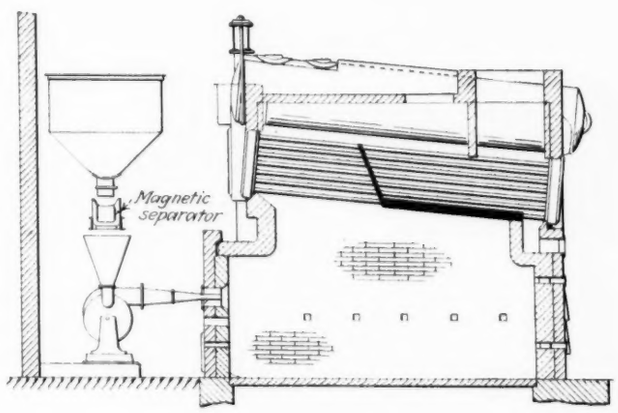


Fig. 2——Unit system arranged for horizontal firing

on test and experience to date) a heat liberation of 5 B.t.u. per cu.ft. per second.

Then the furnace volume required will be $\frac{3{,}550 \times 13{,}000}{3{,}600 \times 5}$, or 2,560, say 2,600 cu.ft.

3. Proportion furnace, calculating combustion temperatures for assumed relation between radiating and heat-absorbing surfaces. Assume: Width of boiler, 8 ft.; furnace height, 26 ft.; height of exposed tubes, 10 feet.

Then the third furnace dimension (front to back) is $\frac{2,600}{8 \times 26}$, or 12.5 ft. and the heat-absorbing surface would be 8×10, or 80 sq.ft.

The heat liberated per hour per square foot of

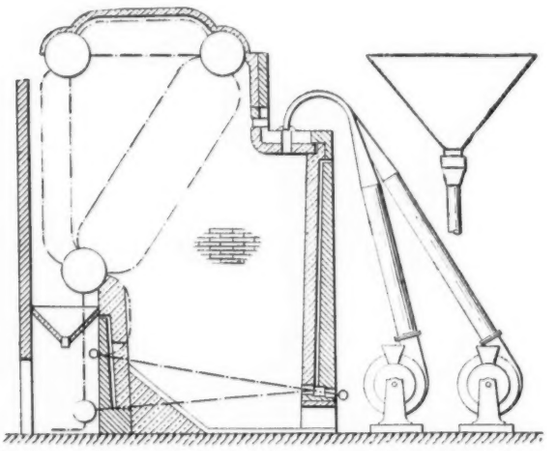


Fig. 3—Typical unit installation with vertical firing

projected exposed boiler surface at 200 per cent of rating is $\frac{3,550 \times 13,000}{80}$, or 576,875 B.t.u., and at rating it will be 288,437.5 B.t.u.

From data based on test and experience the average furnace temperatures at the rating limits and varying CO_2 will be as follows:

	Per Cent CO_2			
Percent of rating	10	12	14	16
100	2,050	2,220	2,340	2,430
200	2,250	2,480	2,630	2,780

4. Give consideration to the type of wall construction and to the advisability of a water screen.

If the arrangement of the boiler and the furnace is to be assumed as satisfactory from the tabulated probable temperatures, it will be seen that with the possible exception of the high rating and the maximum of CO_2 there will be no severe service put on the walls of the setting. This extreme condition can be handled by properly placing a proportion of the air inlets near the top where the heat is likely to be the most intense.

If there is to be a question of incomplete combustion, it will occur at the other extreme and with the low CO_2 where the temperature will show only 2,050 deg. Unless the ash has a low fusing point, it will not be advisable to put in a water screen, which would act to lower the temperature even more.

Therefore the balance of the air inlets may be placed advantageously around the bottom of the furnace to keep the temperatures there within reason for the higher ratings, and the setting should perform satisfactorily with any coals except those of low volatile content where the temperatures must be higher to support satisfactory combustion. This condition could be obtained by raising the boiler somewhat to expose less of the tubes to the radiation.

5. Check gas velocities and stack proportions. This is a point that has caused trouble at times due to not having correct initial information on the capacity of the stack to maintain the necessary draft conditions. It should be checked as soon as the layout has reached the point where the data are complete. There should be capacity for draft sufficient to maintain a slight minus pressure at the burners at the maximum rating.

6. Locate and proportion burners. Assume (quantities set by experience) capacity per square inch of projected area per hour of 15 to 20 lb., maximum width of burner front to back, 4 in., maximum variation of burner width 2 in.

Then the total maximum burner area required will be $\frac{3,550}{20}$, or say, 200 sq.in.; total length of burner area $\frac{200}{4}$ or 50 in.; distance each side to walls $\frac{96 - 50}{2}$, or 23 in.

This last figure is as close as the flame should be allowed to come to the walls, and there will therefore be substantially a continuous opening for the burner of 50 in. The burner itself should be made in sections, and should present as little of exposed area to the action of the heat in the furnace as possible. It should be not closer than two feet from the front wall.

By making provision for adjustment in the distance front to back, it may be set for the low limit by closing

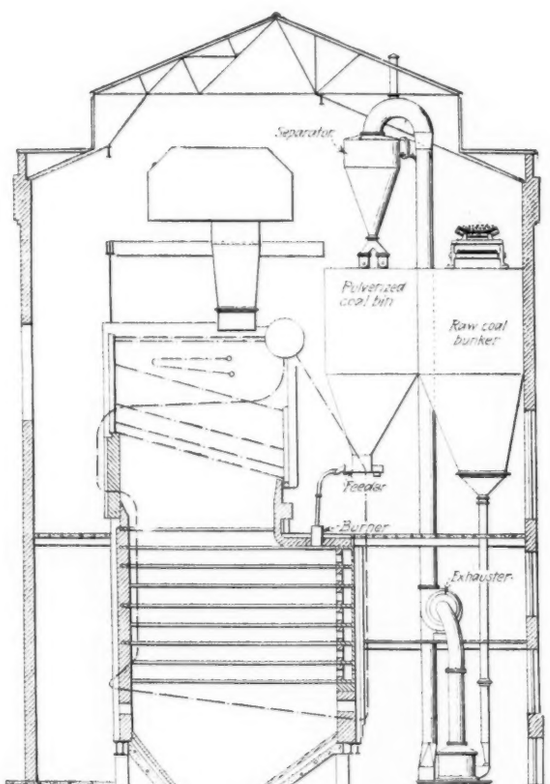


Fig. 4—Typical layout of storage system

it in to but 2 in. of opening. The air passing in with the coal in the unit system should average between 50 and 75 per cent of that required for combustion, depending on the fluctuations in the rating with the idea in mind of keeping the velocities in the fuel pipes and the attendant coal-conveying conditions as near a constant as possible.

7. Proportion air ports in proper locations. The air that is not carried in through the burner must enter through the air ports and serve the double duty of keeping local temperatures at the correct points as well as to complete the combustion.

In the design of the furnace, part of these ports were called for at the top of the setting and part at the bottom. Further, in the fluctuation that has been assumed in the example the ports should be proportioned to admit approximately 50 per cent of the air required. Then by shutting them off progressively as the load falls, the fuel-pipe conditions can be kept at normal and the cooling effect of the ports themselves can be kept under control.

The fact must not be lost sight of that the ports at the bottom will be subject to considerably more draft than will those at the top of the furnace owing to the chimney effect of the vertically fired boiler.

8. Determine on and locate pulverizer equipment. One of the advantages of the storage system is in the storage of prepared fuel between the boiler and the machines in the event that the latter go out of service temporarily. This advantage may be minimized by installing duplicate equipment which is actually not so expensive an undertaking as might at first appear.

When loads fluctuate, for example, as they have been taken in the calculated case, two pulverizers are to be recommended. One can be shut down when the requirements are low and materially save on the horsepower input. Two individual pipes may be run from the machines to the setting and be piped into a common adapter provided with shutoff gates. Then when the load falls off and the burner opening is closed down, a machine is taken off the line and an exact balance is maintained.

In the example taken, two machines of one ton each per hour will fit to the best advantage.

Points To Be Considered in Choosing a Unit Machine

There are a number of unit machines available that may be chosen from, and in making this choice there are certain points that may be borne in mind to advantage. In general the manufacturer who is in a position to make a complete installation is able to render the most ultimate satisfaction. The unit pulverizer that comes the nearest to eliminating grinding elements or actual contact between working surfaces will be able to handle moisture to the best advantage. The machine that comes the nearest to removing the coal of requisite fineness from any part of the mill as it is formed will give the best results with the least power input. Every portion of fine coal that is allowed to remain in the working area after it has been reduced and every portion that is returned from collectors to the feed end of the machine will only serve to cushion the coarser particles against whatever action is working to reduce them to fines also. The machine that has the greatest product of area of working elements, times velocity of travel, other conditions being equal, will tend to give the most uniform results and the longest life of the working parts.

Safeguards against breakage, ease of replacement of working elements, cost of repair parts, compactness of design, ability of the feeder to feed uniformly under varying conditions of moisture, strength of shaft and ample size of bearings, self-aligning features of the rotating elements, automatic stoppage and starting of feed in case of clogging, lack of pulsation in the delivery, absence of vibration, control of the air passing through the machine are all important points.

A great deal more might be written on this subject of the machine design, but it is necessary to complete the outline of procedure before it is lost sight of in discussing matters purely mechanical. It will therefore suffice to say, with regard to the settings for the machines themselves, that the following points should be observed:

The machines should be placed to give as direct a run for the fuel pipe as possible. They should not interfere with the removal of ashes. They should fit in with the arrangement of coal bunkers, provision being made for opening them readily for inspection.

9. Layout fuel delivery pipes, coal bunkers, and coal delivery to the machines.

With the machines and the burners set, the problem in the fuel-pipe layout is limited to connecting the two. The area should equal the maximum opening of the burner, and when the two machines are used the total is evenly divided.

There should be no sharp turns and the section should be round. When the width of the burner is over a dimension where the coal cannot be spread (the example given is about the limit and then an easy sweep adapter will be needed provided with deflectors), the pipe must be branched. In this event deflectors are generally required at the Y to keep the distribution in the branches uniform. They should be designed so that they will deflect the direction of the mixture with a minimum of choking of the open area.

While the main bunkers may be located at a distant point, there should be provision above the machines to carry coal enough to last several hours in the event of the supply being temporarily cut off from storage. Any crushing operations are preferably to be located ahead of this service bunker. The delivery to the feeder should be as near vertical as possible and should be arranged for removal, on occasion, by providing a joint at the pulverizer and a gate under the bunker.

Tramp Iron Separator Essential

10. Specify and locate electric separator. The delivery to the service bunker should include the essential electric separator to remove tramp iron from the coal, for without this piece of equipment there will be certain interruptions to service.

It is of advantage to connect the automatic feeder stop with the current to the separator so that the feeder will be inoperative unless the separator is properly energized.

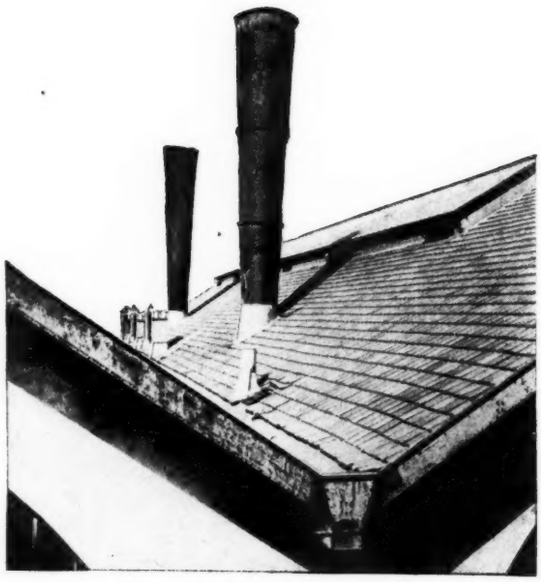
11. Specify and recommend accessories and control instruments. There then remains the selection of accessories and control instruments to make the proposal complete. For this point it is sufficient to say that blowers for removing soot, instruments for measuring pressure, recording steam flow and keeping a check on the draft through the various passes and on the flue gas are essential.

The fact stands that the success of the installation depends, more than anything else, on the degree to which the prospective user is willing to consider it as a primary, essential part of his industry and place it on a sound basis for attention, check and control within the limits for which it is proposed.

If he will do these things, he will find that his power plant represents a powerful assistant in the profitable manufacture of his product. If he will not, then he has just another installation which, as the central-station engineer knows, means but little added resistance to that company one day becoming just another of his subscribers.

The Stream-Line Stack

THE cheminée évasée, Prat, venturi, or convergent-divergent stack, as it is variously known, is widely used in Europe, but is not well known to American engineers. This article gives its genesis, corrects popular misapprehensions as to its principles and shows some of the forms through which it has passed in the process of development.



MODERN practice of operating boilers at high rates of evaporation results in the discharge of large volumes of gas at a high temperature. The use of economizers and air preheaters for the purpose of recovering some of this heat reduces the over-fire draft by lowering the temperature of the gases and adding resistance to their flow. Cinder catchers, when used, increase the difficulty. It becomes necessary, therefore, in many cases to assist the natural chimney draft by mechanical induction. This is usually done in American practice by interposing between the boilers and the chimney a fan of sufficient size to handle all the gases and develop sufficient draft to draw them off from the boiler and to maintain the desired over-fire draft pressure.

In 1892 Louis Prat, of Paris, developed a mechanical draft device for use in an ammunition factory to remove corrosive fumes without passing them through a fan. His process consisted in forcing a current of air into the throat of a stack shaped like a venturi tube, as indicated in Fig. 1, thus inducing a draft which drew off the corrosive gases. This arrangement was later changed to that shown in Fig. 2 and later still to the ejector with an annular discharge having an emergency or supplementary steam jet, as in Fig. 3.

It soon became apparent that this type of stack could be used for producing induced draft for boilers. Its principal advantage lay not in any superior efficiency of the ejector-method over the usual means of moving gases by fans, but in the fact that a much smaller fan could be used. Consequently, the original and maintenance cost of the installation was less and a saving in space was effected. This advantage was emphasized when the fan was made to use a portion of the flue gases themselves as the impelling fluid instead of an additional volume of outside air, as shown in Fig. 4. The enlarged section above the throat of the stack permits a gradual reduction of velocity without diminishing the flow.

The "venturi stack," or "cheminée évasée," was widely adopted in Europe and, in the light of the experience gained by its inventor, had been highly developed at the time of his death some three years ago. The Société des Cheminées Louis Prat, 21 rue Lord Byron, Paris, is now managed by his son Georges J. Prat, and the Establissements Emile Prat-Daniel, 64 rue de Miromesnil, is managed by another son, Emile Prat. Both firms manufacture air preheaters, as well as the draft-producing apparatus.

Few Installations in America

In America the cheminée évasée has, as yet, been little used. The Schutte & Koerting Co., well known as a manufacturer of induction apparatus for various purposes, has installed a few without conspicuous success in attracting the favorable notice of power-plant designers. The stacks of the Trenton Channel station of the Detroit Edison Co. are of this type in appearance only, having the divergent or évasée form but with ordinary large fans handling all the gases at low velocity, and were not intended to have any technical advantage over the common cylindrical type of stack. There has been recently established in New York the Prat-Daniel Corporation for the American exploitation of the products as made by Emile Prat, and it is to Louis C. Whiton, president of this corporation, that *Power* is indebted for the following information concerning this apparatus in its latest form.

In order to describe the various uses and aplications of the Prat or convergent-divergent stacks, they will be considered along with the form of induced draft most familiar to American engineers. This gives us three classifications:

1. The usual draft installation found in the United States, in which a fan forces the products of combustion into a breeching leading the gas to a cylindrical stack.

2. The form of convergent-divergent stack (type I) new to this country and shown in Fig. 5, in which all the gas is passed through a fan and forced directly upward into the throat of the diffuser, or divergent portion of the stack. This type of stack may be made with a single fan, as shown in the figure or with a pair of fans.

3. The convergent-divergent stack (types II and III) shown in Figs. 4 and 6, which operates on the principle of handling only a portion of the total gas through a small fan and forcing it at a comparatively high velocity

through a nozzle in the throat of the stack, thus ejecting the main portion of the gas along with it. This type of stack may also be divided into two classes—the stack with exterior fan as shown in Fig. 4, and the stack, Fig. 6, with interior fan ejecting a portion of the gas through a nozzle directly above the fan.

Fan and Cylindrical-Stack Installation

There are certain resistances that exist between the outlet of the fan and the top of the chimney. These resistances are generally compensated for partly or wholly by the natural draft of the chimney itself, and in consequence, less attention than should have been, has been paid to them. Nevertheless, if they can be reduced and the natural draft maintained, less power will be consumed in the operation of the fan for a given draft, since draft loss means increased power for fan operation. This resistance is due mainly to:

1. Resistance in the Breeching Connecting the Fan and Stack—The outlet of a fan is necessarily limited in size for reasons of fan efficiency. The inlet of the breeching into the stack is somewhat larger than the outlet of the fan, but the average section of this breeching is generally far from the ideal section for the passage of the gas with low resistance. The velocity of the gas in the breeching is frequently 3 to 5 times that in the stack, and since the resistance varies as the square of the velocity, the resistance for a given length will be approximately 9 to 25 times that in the same length of stack.

2. Resistance Due to Change of Direction—The breeching frequently has a bend in it on the way to the stack. In addition it must enter the stack at an angle, at best, of 45 deg. and frequently 90 deg., and all such changes cause draft loss.

3. Resistance Due to Change in Section—In view of the fact that there is a difference in section between the stack and the breeching entering it, there is a considerable draft loss. This loss is proportional to the square of the difference in the velocity in the breeching and that in the stack.

Although it is probably little appreciated, the draft loss at this point is generally the greatest of the three cases cited. For example, with gas at 450 deg. F., the density $D = 0.0436$. Assuming a velocity at the point where the breeching enters the stack of 80 ft. per sec. and a velocity within the stack of 20 ft. per sec., then,

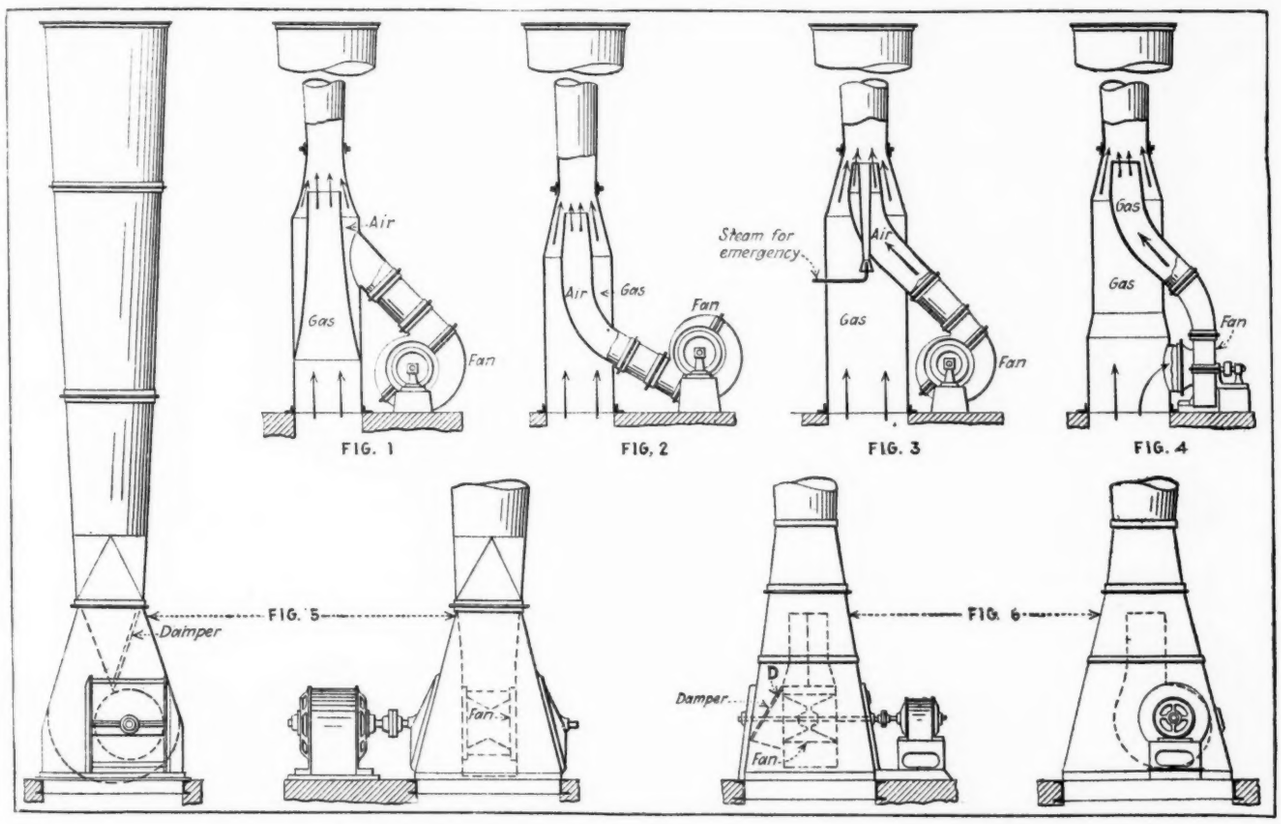
$$\textit{Draft Loss} = \frac{D(V - v)^2}{2g \times 5.197} = \frac{0.0436(80 - 20)^2}{64.4 \times 5.197}$$

$$= 0.48 \textit{ in. water.}$$

4. Eddy Currents—When the gas issues from the breeching into the stack, eddy currents cause a further loss in draft.

Stacks with a Fan in Their Base Passing All the Gas

Assuming that a type I stack, Fig. 5, has the same height and the same natural draft as a fan and cylindrical stack installation, the power consumption of the fan will be less in the former installation. To bring



Figs. 1 to 6—Development and various types of convergent-divergent stacks

Fig. 1—Original Prat design using air as ejecting fluid, introduced around central nozzle. Fig. 2—Next step in development, air as ejecting fluid discharged through a central nozzle. Fig. 3—Same as Fig. 2, except that emergency steam ejector has been added. Fig. 4—Next step in development, gas as ejecting fluid discharged through central nozzle. Fig. 5—Stack with one interior fan, handling all the gas. Fig. 6—Latest development in ejector form of stack, having interior fan and ejecter.

this out more clearly, assume that in comparing the two systems of stacks, they both have natural draft of 1 in. at the same gas temperature. If the draft loss in the breeching and due to friction losses, changes of direction, change of section and eddy currents, is equal to 0.6 in. and the draft required at the inlet of the induced-draft fan is 2 in., then the fan will consume the power necessary to produce an actual draft of 1.6 in. Assuming the same conditions but the elimination of resistances in the stack connections, if the natural draft is 1 in. and the required draft at the inlet of the fan is 2 in., this fan will consume the power necessary to produce a draft of only 1 in. instead of 1.6 inches.

The resistances previously mentioned for the fan and cylindrical-stack installation are eliminated to a large degree in the type I stack, Fig. 5. If the angle of divergence of a fluid is adhered to, there is comparatively no resistance to the passage of the gas within the stack itself, and there are no changes in direction of the gas flow from the fan until it issues into the atmosphere.

Practically, there is a slight resistance to the flow of the gas in the stack, since the ideal cannot be attained, but the effects of this resistance can scarcely be noticed in the power consumed by the fan, and for purposes of general discussion may be disregarded.

An induced-draft fan directing the gas upward into the base of a cylindrical stack approaches in principle the type I stack, chiefly because it avoids the draft losses due to the change in direction of the gas flow

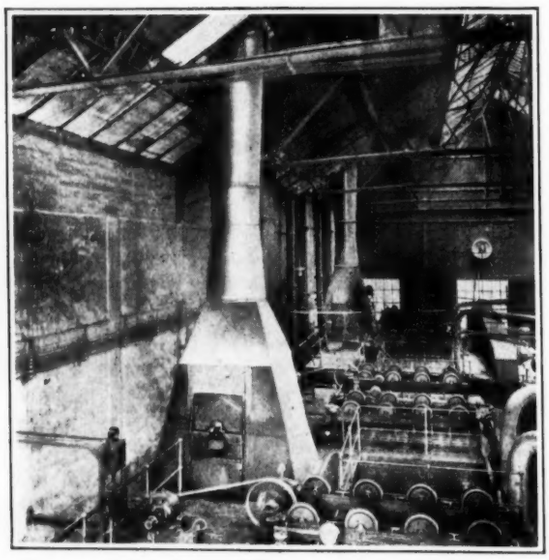


Fig. 7—Base of two stacks each with a single fan serving two boilers

between the fan and the stack. The convergent-divergent stack, however, adheres to the angle of diffusion of a fluid from a nozzle, and unless this is done, there is still a considerable loss of draft and increase in power consumption on account of the change in velocity from that at the fan outlet to that in the cylindrical stack.

The necessity of maintaining as low power consumption as possible for induced draft becomes vitally important for the operation of modern boilers at high rating, owing to the fact that the resistance varies as the square of the gas velocity (volume), and the power necessary to discharge the gas through a given section increases as the cube of the volume.

This is brought out in the following tabulation, taken

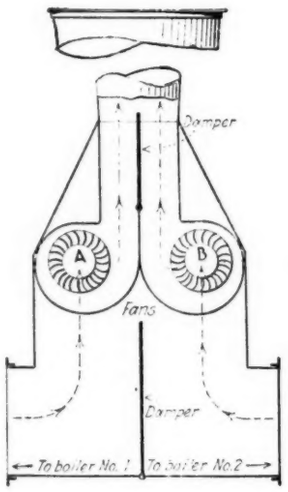


Fig. 8 — Diagram of stack with two internal fans and two dampers, serving two boilers

By using the two dampers, there are nine possible combinations of the two boilers and two fans that may be used. For example with both dampers in a vertical position in the figure, fan *A* is on boiler No. 1 and fan *B* on boiler No. 2. By throwing both dampers to the left, boiler No. 1 is cut out and fan *B* is on boiler No. 2. If the lower damper only is thrown to the left then boiler No. 1 is cut out and fans *A* and *B* are on boiler No. 2. There are six other combinations that can be made.

from the Bureau of Mines, Bulletin No. 21, "Significance of Drafts in Steam Boiler Practice":

Per Cent Boiler Rating	Steam Used by Fan in per Cent of Steam Produced	Per Cent Boiler Rating	Steam Used by Fan, per Cent of Normal
100	2	500	50
200	8	600	72
300	18	700	98
400	32	800	128

Although the starting point is high in this table, it serves to show that by saving a small amount of power at low ratings, the saving becomes large at the higher ratings now being approached in boiler-plant operation. The type I form of stack is suitable for boilers operated at high ratings, requiring high draft, as well as those requiring low draft.

Stacks with Fans Passing Part of the Gas; Ejector Principle

This form of stack is suited for low drafts or for special uses. The type II stack, Fig. 4, with exterior fan is the design that is perhaps best known to American engineers and frequently called "évasée," or "venturi" stack. It operated successfully, but was handicapped by the fact that the portion of the gas used as the ejecting fluid was forced at a comparatively high velocity through a fairly long breeching having at least one turn in it, which created considerable resistance. This stack still has its uses, such as in the evacuation of abrasive kiln gas or corrosive and extremely high-temperature gases, since air can be used as the ejecting fluid and the maintenance costs on the fan reduced.

In the ejector form of stack, shown in Fig. 6, the breeching is entirely avoided by having the fan, fan casing and ejector placed within the stack itself; thus avoiding the breeching draft losses. This type has a damper *D*, which, when closed, changes the fan from a double to a single inlet. The draft can thus be varied without changing the speed of the rotor and without introducing further resistances in the gas path, as would be the case if ordinary damper regulation was used.

For a given quantity of products of combustion the

size of the fan for the type II stack is about one-third as large as the induced-draft fan handling all the gas. This is for two reasons: First, only a portion of the gas passes through the fan; and second, this gas is forced through the fan at a higher pressure than would be used if the fan handled all the gas. It will thus be seen that the advantage from the viewpoint of first cost is in favor of the type II or type III stack, over either the type I stack or the fan and cylindrical-stack installation.

Since the fan for the types II and III stacks is smaller than for the other types, the comparative maintenance cost would be in favor of the smaller apparatus. The space occupied would also be less, and this is frequently of considerable importance. Although the power consumption of this form of installation is comparable to that of an induced-draft fan and cylindrical stack, the power consumed is practically constant over a considerable range, as shown by curve ***F***, Fig. 9. This type of installation would therefore be preferable

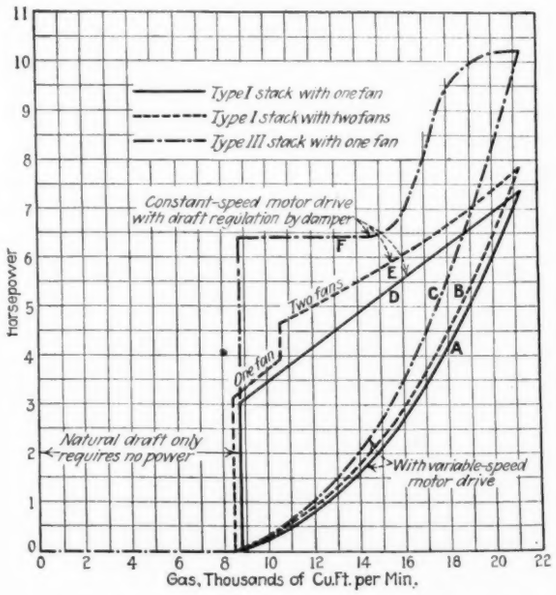


Fig. 9—Curves showing comparison of power consumption of fans in two types of stacks

These curves are based on a specific case handling 21,000 cu.ft. of gas per minute at a temperature of 392 deg. F., and 1.4 in. of draft at the base of a 49-ft. stack.

if a boiler must operate under loads varying within certain ranges and with comparatively low draft requirements, since the power at a given intermediate rating may be even less than the type I stack, owing to the flatness of the efficiency curve of the type III stack.

In general, however, the power consumption of the type III stack is roughly 1.4 times that of the type I with a fan within its base, as indicated at the maximum ratings shown in Fig. 9, but the manufacturing cost of the type I stack is about 1.4 times that for the ejector form. The number of hours of operation per year of the boiler installation, the intensity of draft required and the cost of power would therefore determine whether a type I or a type III stack should be used.

Both types I and III use a double-inlet fan, which has the advantage of even balance on the shaft and smaller diameter of rotor, running at a somewhat higher speed than would be the case with a single inlet fan. For direct drive this higher speed permits the use of a less expensive motor for a given horsepower fan than would be the case for low speed. Both forms of stack are comparatively light and in operating practice are generally placed directly over the boiler or the several boilers that they serve.

In Fig. 7 is shown the base of two stacks, each with a single fan, furnishing the draft for two 5,000-sq.ft. boilers, equipped with economizers and preheaters, placed in the line before the economizers.

This brings up the question of the use of a convergent-divergent stack in connection with several boilers. The best control can be obtained when operating with a single fan in connection with each boiler. However, owing to the small size of the fan of the type III stack with ejector, it can be used with several boilers better than a single induced-draft fan handling all the gas, which would then become too large. The same observation of using a single fan per boiler, holds true with a type I stack having one interior fan. These stacks are also made with two fans on the interior, each serving one or more boilers. This reduces the cost of the stack and the induced-draft installation per boiler and is to be preferred because of the flexibility of operation.

For installations requiring continuous operation, it is desired that as many causes of interruption of draft as possible be eliminated. By the utilization of two fans in the base of the stack, with a double damper serving two boilers, as in Fig. 8, there are nine possible arrangements of the two fans and the two boilers that may be used. Therefore, if a motor or a fan is out of commission, the motor or fan can serve one or both boilers by regulation of the double damper. In order to make operation more certain, one fan can be connected with a turbine and the other with a motor.

The use of variable-speed motors, for variation in draft, is desirable. However, with an alternating-current motor having two or three speed changes only, effected by changing the number of poles, different amounts of drafts can be obtained when using the two-fan stack. By operating fans *A* and *B*, Fig. 8, at the maximum speed of the motors, the highest draft will be attained. There are then various combinations of the two-speed motors, such as fan *A* at full speed, or both at half speed, or the operation of one fan at full or half speed. This rough variation of draft used in connection with a damper at the boiler will give practically all the drafts desired.

There are three positions at which the damper in the single-fan stack, Fig. 5, can be placed so as to vary the draft without changing the speed of the fan and without introducing resistances in the flow of gas. When natural draft is to be used, the damper would be in the position indicated by the dotted line at the left of the figure and the gas in this case would bypass the fan. When the damper is in the center position, a portion of the gas would be drawn through the fan and the remainder would be bypassed and ejected up the stack by the gas passing through the fan. This would give a lower draft and a lower power consumption, and the principle used would resemble that of the ejector-type stack.

There is shown in Fig. 9, curves giving the power consumption for a particular set of conditions for the type I stack with one fan, the type I stack with two fans and the type III stack with ejector. These curves must not be taken as a general comparison of the operation of the different forms of stacks that would be

true in all cases. They are based on an average case with all three stacks operating under the same conditions of 21,000 cu.ft. of gas per minute, a required draft at the base of the stack of 1.4 in. with a gas temperature of 392 deg., and a stack 49 ft. high.

Two cases have been taken into consideration:

1. With variable-speed motor, adjusting the fan's speed to draft requirements, curves *A*, *B* and *C*. In this case the efficiency of the installation would be at its highest.

2. With constant-speed motor, the draft regulated by a damper, curves *D*, *E* and *F*.

A comparison of these curves shows:

A. The type I stack equipped with one fan is the most advantageous from the viewpoint of the power absorbed, curves *A* and *D*, whether it is to be equipped with a constant-speed motor or a variable-speed motor.

B. The type I stack with two fans absorbs slightly more power than for one fan, curves *B* and *E*, but the two fans operate at a higher speed, which is an advantage for direct connection with the motor, and this type of stack is to be recommended where the stack is to operate with one boiler or with two boilers.

C. The type III stack, using the ejector principle, absorbs a greater amount of power than either of the other two arrangements, curves *C* and *F*. Its advantage is lower cost of installation.

With different conditions of operation, needless to say, these curves would be somewhat changed.

Stoker Operation in the Industrial Plant

By I. R. Hoffman

AS STATED in *Power* some time ago, a great number of plants are still operating with nothing more than a pressure gage to show results. It is not so much a matter of equipment as of method that raises the ire of the men who are called in to make recommendations.

Another thing that puzzles some of our combustion experts is that almost every stoker-fired plant has a method of operation almost all its own. Many of these plants, oddly enough, use the same equipment and have somewhat similar load conditions. Of the many methods in use, the following is submitted as showing efficient results and is probably simpler than most of them to maintain.

This method employs the fuel-bed resistance as a guide. The matter of thickness of fire, ashpit pressure, damper opening and stoker feed are often all variables. This is needlessly so and will be found to be unnecessary.

It is of advantage to employ the principle of balanced draft in order to maintain a constant draft over the fire. The fire is first cleaned and built up to average thickness. The damper is set to get about 0.03 in. of draft over the fire. Now without paying any attention to the draft gages, the pressure in the ashpit or windbox, whichever the case may be, is adjusted until about 12 to 15 per cent CO_2 is obtained. The draft gages now read, let us say, as follows: Ashpit pressure, 1.5 in.; over fire, 0.03 in.; back damper, 0.5 in.

The stack damper can be kept at 0.5 in. by adjusting the ashpit pressure. These two should be closely watched. When more than 1.5 in. in the ashpit is required to obtain 0.5 in. at the back damper, the fire is getting too heavy or too dirty. The remedy is then either to slow up the coal feed in the first case or to clean the fire as soon as possible in the latter.

If 1.5 in. of pressure cannot be put on in the ashpit to obtain 0.5 in. at the damper, then the fire is too light or there are holes in it. The usual remedy is to speed up the stoker feed. If the coal is fed in too fast, the stack damper gage will show a low reading, thus calling for more ashpit pressure. Should the coal be fed too slowly, the damper gage will show increased opening, calling for less ashpit pressure and increased coal feed until proper conditions are restored.

By increasing the thickness of the fires and raising the ashpit pressure, peak loads can be met and successfully carried. Smokeless, or nearly smokeless, combustion should result. When burning high-volatile coals, a high setting and ample combustion space is a necessity for smokeless operation. If preheated air is used, to assist in burning the volatile element, a marked advantage in more nearly smokeless operation will be noted.

A worthy consideration in these days of smokeless campaigning is the use of auxiliary preheated air to raise the efficiency of combustion. Experience has shown that the use of preheated air results in considerable improvement in combustion. About fourteen pounds of air are required to burn one pound of soft coal completely, but only half of this, in the writer's opinion, should be admitted through the stoker grate, the remainder being supplied over the fire. If this can be well preheated, smokeless combustion is practically assured. When using preheated air, the best place to admit it is right over the coking zone or in the front of the furnace. Here the great quantity of gases distilled from the coking coal is mixed with the auxiliary air and burns completely, at the same time effecting smokeless combustion.

This is not an arraignment of the use of air preheaters and the methods of introducing heated air through the stoker grate. It is merely an attempt to show one practical and effective way to improve furnace efficiency in the average industrial plant.

In low-temperature refrigeration it is sometimes necessary to operate with a vacuum constantly on the coils. Compressors designed for this purpose have stuffing boxes so arranged that there is always an outward pressure, thereby preventing the inward leakage. But it often happens that compressors intended for use on back pressures above atmosphere are made to work on a vacuum. This may happen when the evaporating coils are clogged or heavily coated with oil and tar, when the expansion valve is choked, or when there is too little ammonia in the system. Whatever the cause, a vacuum maintained on a machine not designed for that condition results in air leakage.

Although a high resistance coil may cause local heating of the commutator and sparking at the brushes, this sparking is not nearly so severe as that caused by an open circuit. In many cases it is not sufficient to attract serious attention. If allowed to exist for a long enough period, it will cause local black spots on the commutator. In a parallel winding only one black spot will occur, while in a series winding a spot will occur for each pair of poles. When the machine is in operation, the defects can be easily located by their effects.

Improve the Industrial Boiler Plant

AN INCREASE of fifteen per cent in the boiler-room efficiencies of our industrial plants exclusive of steel works, would effect an annual coal saving of eighteen million tons, representing roughly eighty or ninety million dollars. A large portion of such saving should be easily attainable at a moderate investment.

How many of the eighteen thousand industrial plants, burning over fifteen hundred tons of coal per year each, are being run around fifty per cent efficiency with low boiler settings, hand firing and other obsolete methods; is a matter of conjecture; a survey would probably show the number to be surprisingly large. By employing improved settings, larger boiler units, mechanical firing and giving closer attention to combustion, it should be possible to raise the average efficiency to sixty-five per cent.

Boilers in industrial plants are now run at higher ratings than formerly, greater flexibility is demanded, and there is a growing realization that opening the furnace door every few minutes is not conducive to proper combustion. Moreover, men expert with the coal shovel are becoming scarcer.

This is an age of labor saving wherein mechanical power replaces brawn, and the principle finds one of its greatest opportunities in the industrial boiler plant. In the up-to-date plants brains have replaced muscle, and there is unlimited opportunity for the smaller and less efficiently operated plants to emulate the example.

Getting Into Complications

OUT of the effort to develop our water powers and at the same time protect the various interests having claim in these resources, all kinds of complications have arisen. Until recently, our Canadian neighbors seemed to have avoided many of the difficulties that beset water-power development in this country. However, the recent proposal to place an export tax on power transmitted out of the Dominion seems to have been somewhat of a boomerang. If the tax is applied as now proposed—that in all cases the exporter of the power must pay the tax—the Province of Ontario will have to pay over one hundred thousand dollars annually for the next twenty-five years to the Dominion Government. As the provincial government is under contract to export power at a fixed rate, the tax cannot be charged to the purchaser, but must be paid out of revenue for power sold in the province. In other words, the power users in Ontario must pay the tax on the power exported into New York State.

The Province of New Brunswick is proceeding with a nine-million dollar development at Grand Falls on the St. John River. As the headwaters of this river are in the State of Maine, the storage capacity which is necessary for the full development of this project will have to be made outside of Canadian territory. Whatever agreement may be made between the Province of New Brunswick and the State of Maine, the latter may be expected to insist upon the right to import a certain proportion of this power from Canada.

If reports are correct, the Northern Electric Company is ready to spend fifty-two million dollars on the Carillon development on the Ottawa River, provided it can obtain a satisfactory export license for the power. Canada will not require this power for many years to come, and when it is needed there will be just as much of it available as there is today. A rational export water-power law, intelligently administered, will attract large capital expenditures, and can also be made a source of revenue through the application of a reasonable export tax. Large blocks of power available will not only attract industries within Canadian borders, but also will attract them to localities in this country that will be of advantage to Canada. On the other hand, such a law unwisely drawn and applied, can be made to defeat the end it was intended to accomplish.

Auxiliary Steam Stations and Water Power

AN EARLIER editorial suggested that the more extended development of our water powers would be accompanied by the construction of additional auxiliary or connected steam plants. It was also noted that these may be needed to tide over periods of low flow or to carry peak loads of the system. Under certain conditions the steam plant may even operate as a base-load station provided sufficient pondage is supplied for the hydro plant. This leads to a consideration of the character of the steam station for such service.

The early idea of an auxiliary station was one that contained rugged units of low first cost. Economy was sacrified to simplicity and low initial investment. Low steam pressures insure boilers of low first cost and generally of small size provided with small furnaces and standard stokers. Steam-driven auxiliaries were general. In many cases jet condensers were provided for the turbines and raw water after some preliminary treatment was used as boiler feed. It was expected that the station would be shut down at frequent intervals so that the boilers could be cleaned at such times. Cheap grades of coal were purchased for such plants.

The location of these steam auxiliary plants has not always been wisely chosen. For instance, a certain steam auxiliary plant was located on the river bank several miles below a power dam impounding a large volume of water. This plant was largely used during periods of low water. In order to provide the steam plant with an adequate supply of cooling water for its condensers, a certain portion of the hydro plant had to be in operation to give the necessary flow in the river. This condition regarding cooling water will fix a definite

limit on the ultimate size of the steam station besides lessening the possibilities of operating the steam and hydro plants to best advantage. The steam plant could easily have been built at the dam. Adequate cooling water would have been available for the largest steam station that might be built in that system. Furthermore, if dam, hydro-electric plant and steam station had been designed as an inter-related whole, the colder waters at the bottom of the pond could have been made available for cooling water to condensers, and this would have resulted in a substantial improvement in steam-turbine economy at little or no additional expense. This idea will undoubtedly be given greater consideration in future designs. The cooling water from condensers may be discharged above or below the dam, depending on head conditions and flow.

Furthermore, a location at the dam would permit the steam station to use the same electrical switching and transmission systems as the hydro plant. The total power sent out would not likely exceed the capacity of the electrical equipment necessary for the full output of the hydro plant.

It has been almost invariably the experience of power companies that the auxiliary steam stations are operated at higher load factors than originally contemplated and that larger investments in more economical equipment would have been more than warranted. The use at high load factors of cheap low-efficiency steam plants saddles the hydro system with high power costs. Engineers who plan such auxiliary plants should therefore give careful consideration to future possible developments of the whole system, particularly with the experience of other systems in mind. Where this has been done and competent engineers have been assigned to the design of the steam stations, plants have been planned and built that will produce power from steam at reasonably low figures and that are capable of considerable further extension. The question of auxiliary steam stations will confront every hydro-electric system in the near future.

The German Alcohol Invasion

THE practical value of scientific research is strikingly illustrated by the synthetic production of methanol, which the Germans are now delivering to this country at a price endangering the local manufacture of wood alcohol, a material which it replaces. As recently pointed out in *Chemical & Metallurgical Engineering*, a tariff excluding the competing product does not get to the root of this problem. The real lesson is that steady and consistent support must be given to scientific research. Results are not obtained by hastily shoving four or five chemists into a laboratory and telling them to work out this or that secret of one's competitor. Consistent productiveness in scientific research requires a well-organized permanent staff working systematically and without undue haste.

In many respects underselling by the importer is of immeasurable benefit inasmuch as it forces competing manufacturers to adopt more modern methods and ultimately make greater profits through the increased demand brought about by the lowering of the price. This has been the history of hundreds of articles that are now in daily use. It is the logical outcome of the alcohol invasion.

As a source of motor fuel, however, synthetic alcohol of either foreign or native origin possesses limited possibilities. Even if obtainable at a price considerably under that of gasoline, its use in the present automobile is not advantageous without modifications in the engine. Not only would the thermal efficiency be lower, due to the low compression, but the amount of fuel used would be almost doubled, for the combustion of a pound of alcohol develops much less than two-thirds of the heat evolved in the burning of an equal weight of gasoline.

To use alcohol economically, the engine's compression must be raised to almost twice the values used in automobiles. This is not impossible, but unless a supply was available at all gas stations, the forced change from alcohol to gasoline would occasion severe engine trouble. As long as gasoline is obtainable at existing prices, alcohol must sell for under fifteen cents to make it competitive. Even then it will require the support of one or more large automobile manufacturers, with modified engine designs to create the demand.

Because of these factors the position of synthetic alcohol is much more secure for industrial purposes than as a fuel. Nevertheless, its wider adoption as a competitive fuel would be highly desirable, not alone from a price viewpoint, but as a means of relieving the tremendous drain on our oil supply.

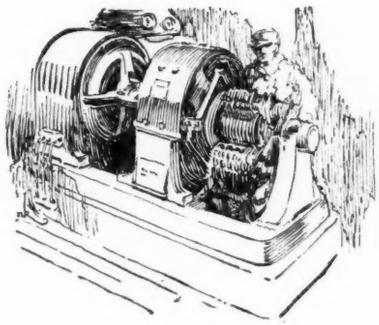
Power-Plant Instruments

BUYING power-plant instruments is much like getting married. Undue haste in selection is likely to be followed by repentance at leisure. Instruments must be lived with. If they prove worth keeping, their indications will guide operation for years to come and have a considerable effect upon plant routine. The practical necessity of indicating and recording instruments as an aid to plant operation is now admitted by all up-to-date engineers. But what instruments are needed, how many, and where should they be located? To these questions the answers must vary from year to year as new advances are made. They must also vary from plant to plant.

In any case two extremes should be avoided. The attempt to operate without instruments is foolish; on the other hand, their installation may be carried to an unwise extreme. As pointed out by R. S. Reed, in his article on Power-Plant Instruments (page 769), all essential instruments should be installed, but the non-essential ones should be omitted. "Unnecessary instruments produce records that are not vital to operation and by adding to the data obtained tend to confuse the interpretation of the useful records." The selection and arrangement of power-plant instruments is a highly important question on which problem Mr. Reed's article throws much light.

To show what astounding results may follow research, one need only point to the recent production of synthetic sugar by passing ultra-violet rays through formaldehyde, which substance, in turn, was made by combining air, coal and water. The latter process sounds strangely familiar to power-plant engineers who have been combining coal and air for years in their boiler furnaces. At any rate, sugar made from coal is food for thought as well as for the stomach. Perhaps the future will see the production of fuel oils from coal in such a manner as to utilize the fixed carbon as well as the volatile combustible matter.

Practical Ideas from Practical Men



WITH a view to stimulating engineers into the habit of recording for the benefit of brother engineers, unusual occurrences, how these were met and other practical expedients adopted in the operation of their plants, Power has decided to award two cash prizes each month during 1925. One of $25 for the best and another of $15 for the second best practical letter on plant operation or practical kinks received during the month. This is in addition to payment for the contribution at space rates. The winners for April will be announced next month.

The Value of an Automatic Engine Stop

In our plant there is a 600-hp. Corliss engine that has twice been prevented from running away by the automatic stop with which it is equipped. In both cases the increase in speed was caused by the backing out of one of the screws that hold the steel pick-up block in place, and preventing the valve from closing, which in turn caused the engine to take steam full stroke on one end. Here is an instance where an automatic device prevented the engine from being wrecked and saved many thousands of dollars.

Undoubtedly, many wrecks have been due to similar causes. We try to keep close watch on all parts that are likely to cause trouble, but of course it is possible for an engine to get into a dangerous condition while in operation. Personally, I would not care to operate an engine that was not protected by an automatic stop.

Once a week we test all push-button controls and the automatic stop. In addition, the engine is always shut down by tripping the stop. Not long ago an engine driving an ice machine ran away, causing considerable damage, but fortunately with no loss of life. The cause in this case was the key coming out of the governor pulley.

Safety devices must be examined frequently and kept in order, or they may fail in an emergency. In too many cases this is not done. J. O. BENEFIEL.

Anderson, Ind.

Problems in Turbine Rotor Balancing

When balancing different parts of turbine rotors on knife-edges, it is important that the work be carried out with great care and accuracy, as in most cases with the larger sizes of units it is impossible to balance the assembled rotors on the shaft. Under these circumstances the complete assembly may be unbalanced, owing to the fact that all the small unbalanced portions of each rotor may assemble in the same plane and cause vibration in the unit. This fact was demonstrated recently in connection with a 1,000-kw. turbo-generating set that was under test on an experimental locomotive. Each separate rotor part had been carefully balanced in the shops, but the complete assembly could not be tested for balance.

The turbine ran successfully in the test shop, but when installed in the locomotive, the vibration was excessive and the unit could not be run for any length of time as the vibration appeared to get worse the longer it ran. The unit was now running under totally different conditions from the test shop, as it was mounted on the frame springs of the locomotives, and these springs appeared to vibrate in step with the turbine vibrations. The machine was finally dismantled and taken to the shop for examination and rebalancing. During the process of rebalancing it was found that practically all the unbalanced portions of the rotors when assembled came in line and were all on one side of the shaft. The trouble was cured by careful balancing, and if any of the rotors were slightly heavy on one side, an endeavor was made to correct this by making the neighboring rotor an equal amount heavy, but at 180 deg. to the first. This, however, is not good practice, as it tends to introduce a rocking couple in the shaft, but in this particular case the results were satisfactory and the unit was tested out successfully on the locomotive. DOUGLAS P. MUIRHEAD.

Glasgow, Scotland.

How Often Should Engineers Change Shifts?

I should like to hear from readers, through the columns of *Power*, what their ideas and methods are of arranging the hours of work for the men they employ in the boiler engine rooms.

Do they consider it a good plan to leave the watch engineers and firemen on the same shift all the time? If so, why?

Do they prefer to change them around every two weeks or so, and why? What are the advantages of changing around other than that it gives men a chance for a show and an evening at home?

Some engineers leave it to the watch engineers and firemen to settle the argument among themselves. Is this right, or should the chief engineer make a schedule for them to go by?

It seems to me that it would be best to change them around about every two weeks, as this will give them a chance to forget the worries of any particular shift. It also will give the chief engineer opportunity to observe the men, as he will have them on the day shift with him and therefore will be able to give them personal instruction where necessary. In my opinion once a month is too far apart, as it gets the man too set in his regular hours and it leaves the man on the most undesirable shift (11 p.m. to 7 a.m.) too long at a time.

Furthermore, it is not fair to leave a man on the

same shift all the time. The one on the day shift is inclined to develop the attitude that he owns the plant and that the other shift men are his inferiors.

In some plants a regular relief man is employed and the engineers and firemen get a day off a week. But where this is not the rule, when a man is off for sickness or other causes the others have to double up and work twelve hours. The employing of a regular relief man is in my opinion a good plan, for in small plants he could fire three days and relieve the engineer the other three days. In this way he would have a steady job and would be able to help out anywhere in the plant in an emergency. This seems a better plan than having one relief man for the engine room and another for the boiler room.

What have some chief engineers to say on this subject?

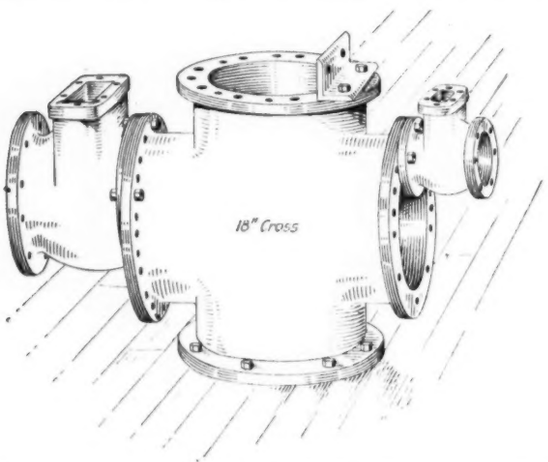
R. G. SUMMERS.

Rochester, N. Y.

Repair of Large Gate Valves

In a chemical plant, where, on account of the corrosive action of the liquors, the repairs of large valves was a heavy item, the following methods of repair were used:

First, it was necessary to drain the line completely of liquor, then the valve had to be removed and replaced with a spare. With a large-sized valve this was no light job, and it usually entailed holding up production



Valves under repair are attached to large cross bolted to the floor

for a considerable time. The valve to be repaired was taken to the machine shop and set up in the lathe and a cut taken off sufficiently deep to remove the pitting. The valve was then turned around and the other face cleaned off. Next, the wedge was faced up until all the pitting had disappeared, then it was trued up on a faceplate and finally spotted into the seat on the valve body.

With a comparatively new valve the wedge would be still a good fit, but after refacing a few times, it would be reduced in size and would not make a tight fit between the seats. This was overcome by taking a ring of thin plate about $\frac{1}{4}$ in. thick, and fitting it accurately to the wedge face, attaching it with small countersunk screws. This was done on both sides, and the wedge put in the lathe and trued up. Measurements of the space between the seats were then taken and the wedge turned down to make a fit at the maximum space, so that there would be enough metal left for subsequent facings. The cost of having to remove these valves was found to be so great, combined with the tying up of the one large lathe for so long time and the fact that it was at times necessary to take them down from the lathe to make way for a more pressing repair job, that the purchase of a valve-reseating machine was considered, and after costs had been thoroughly investigated by a somewhat skeptical manager, a machine was finally bought.

It was then possible to reface a 16-in. valve in about four hours, including taking a cut off the face of the wedge. Where the wedge was worn down, a spare was inserted and the old one repaired at leisure.

In connection with the repair of valves that have been removed or salvaged, a handy rig was made from an old 18-in. cross that was recovered from the scrap heap where it had been thrown on account of a crack in the body.

Extra holes were drilled in three faces, and the other flange was bolted to the floor. Valves to be reseated or repaired were then attached to the two opposite flanges and secured with bolts, as shown in the illustration. By this means a man could work on the seat of one, while a helper was setting up the next one and opening it up ready for the reseating machine. On the top flange an angle iron with slotted holes was bolted for fastening small valves. This facilitated the repairs to a considerable degree. Of course it is not necessary to use such a large cross, but as this one was available it was pressed into service rather than to procure a new one.

MAURICE C. COCKSHOTT.

Los Angeles, Cal.

Combined Suction Air Chamber and Strainer

For several years the plant of the United Paperboard Company at Wabash, Ind., has been handicapped in its process water supply, both as to quantity and quality. The mill originally was supplied with water from driven wells, but these proved so difficult to keep in order that it was found necessary to abandon them, and two lines of suction pipe were installed connecting the mill pumps with the Wabash River. These suction lines are 16 and 20 in. in diameter, respectively, and 1,200 ft. long, being made up of cast-iron bell-and-spigot pipe with leaded joints.

The original pumping equipment consisted of one 14x14-in. double-acting triplex power pump, one 18x30-in. single-acting duplex power pump and an 18x11x16-in., 1,500-gal. per min. fire pump. It was difficult to keep these pumps in good order. The grit contained in the river water scored the pump rods and cylinders, cut out the piston packings, etc., causing continual repairs as well as numerous shutdowns which seriously affected the mill's production.

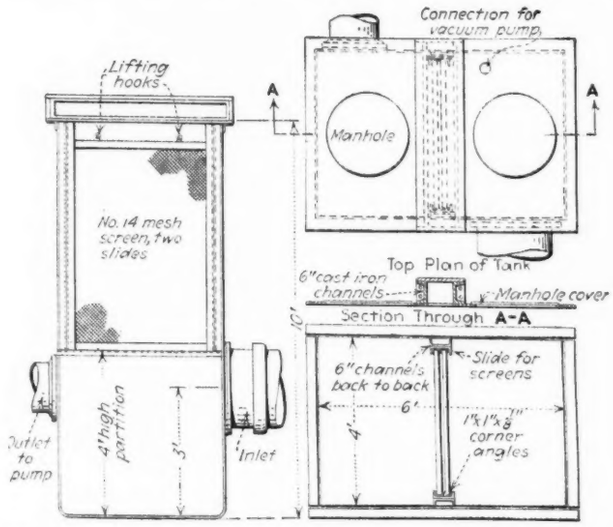
To improve the quality of the water a brick cistern 25 ft. in diameter was sunk to a depth of several feet below the river bottom. This cistern is near the mill in a field that is flooded every spring and fall when the Wabash River overflows its banks. Under the top soil the field is a large sand and gravel bed yielding at favorable times sufficient water of excellent quality to meet the demand of the mill for process water.

Circulating water for the condensers is pumped from the river and, after passing through the condensers, is

discharged into a small pond surrounding the brick cistern and filters through the sand and gravel into the cistern, thus assisting the natural ground water supply.

In 1923 the power pumps were replaced with two motor-driven direct-connected 10-in. centrifugal pumps, the main supply pump being connected to the 16-in. suction line and the circulating pump to the 20-in. suction line. At a distance of approximately 200 ft. from the pump, at the location of the cistern, the 16-in. suction line branches, one branch continuing to the river and the other running into the brick cistern. Each branch is equipped with a gate valve to permit of adjustment to control the water level in the cistern. In operation, as much water is taken from the cistern as its capacity will permit and the remainder from the river. At certain periods of the year the cistern yields the total requirements of the mill.

Upon the installation of the centrifugal pumps it was found that, while the maintenance costs were



Elevation and plans of combined suction air chamber and strainer

reduced and in general the pumps proved satisfactory, they were incapable of handling the air consequent to the long suction pipe from both leakage and the air given up by the water under a lowered pressure or vacuum. The air in the suction pipe caused considerable loss of capacity as well as excessive wear on the impeller sealing rings, these difficulties increasing or decreasing as the water level in the river fell or rose.

After several unsuccessful efforts were made to eliminate the air by recalking the joints and other means, it was decided to install a tank or suction chamber in the suction pipe close to the pump. This vacuum surge tank is 4x6 ft. in horizontal cross-section and 10 ft. high. A vacuum pump is connected to the top of the tank for air removal. The tank is fitted with a solid partition 4 ft. high between the inlet and the outlet, and above the partition double ¼-in. mesh wire screens extend to the top of the tank. The partition and screens prevent sticks, leaves, etc., from entering the pump. It is intended to renew this screen gradually with finer-mesh wire until the finest mesh practical is determined. The top of the tank is fitted with manholes and a cover over the screens to permit their removal.

Special attention was given to the design of the surge tank to insure permanent tightness and make it possible to do any necessary calking or repairing from the inside of the tank, as it was intended to bury the tank underground. Subsequently, the tank was placed in a concrete pit, making it possible to inspect or repair it inside and out. The tank is fitted internally with angle-iron stiffeners to prevent any tendency to collapse or breathing action. In operation a vacuum ranging from zero to 14 in. is maintained, depending upon the height of the water in the river.

WILLIAM A. DAVIDSON, Chief Engineer,
Wabash, Ind. United Paperboard Co., Inc.

Cooling Medium for Turbine Oil Cooler

Modern installations show a tendency to apply condensate as a cooling medium for the generator-air coolers, turbine- and transformer-oil coolers, as well as intercoolers and after-condensers for the steam-jet air pumps. An extreme case would be to use condensate for the hurling water in a hydraulic-vacuum air pump without subsequent deoxidizing except that taking place in economizers, etc.

The main argument advanced for the use of condensate in the aforementioned heat-transfer apparatus is the thermal gain. The trouble is that too many think in terms of quantity of heat rather than in terms of both quality and quantity. By quality is meant the temperature or thermal elevation of heat. The heat that is abstracted from the generator-air coolers, turbine-oil coolers and steam-air-jet intercoolers, is a low-temperature, low-grade heat. At this temperature range one pound of water can be raised 1 deg. F. with approximately 0.1 to 0.2 of the B.t.u. absorbed as available for doing work, provided the low-pressure-stage bleed is used. It is hardly worth while to sacrifice both flexibility and reliability for such a small thermal gain. Even this gain will be more than offset by decreasing the amount of heat that can be abstracted from the low-pressure turbine bleed and in complicating the station layout.

Another argument in favor of using condensate is that it saves the tube cleaning, which appears to be unfounded. For instance, with oil coolers the factor that limits the heat transmission is not the water side but that in contact with oil. That is, it does not make any difference practically how dirty the water side is, as far as the oil cooler performance is concerned. An analogy is the case of two electrical conductors identical as far as the dimensions are concerned, but made of different material and placed in series. The current-carrying capacity of the circuit is limited by the conductor having lower conductivity.

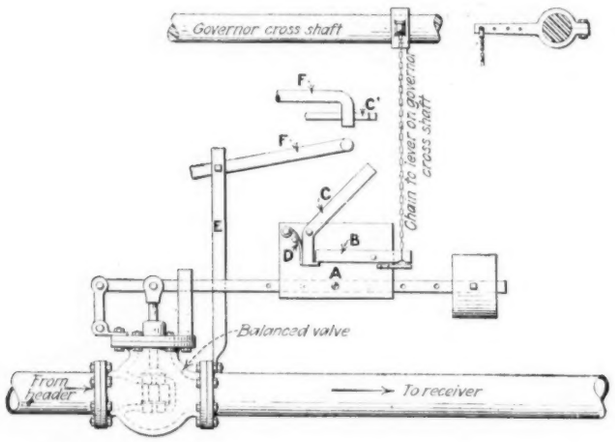
The condensate is necessarily warmer than the circulating water, and although it will keep the water side clean, this is at the expense of the oil side. The factor that governs the interval of oil-cooler cleaning is the condition of the surface that is in contact with oil. When oil temperature is increased, more frequent cleaning is necessary, and the higher the temperature of the cooling medium is, the more rapidly oil deteriorates. In dealing with any apparatus for heat transmission, only the limiting factor should be considered. The chain is no stronger than its weakest link, so that the coefficient of heat transmission is limited principally by the poorest conductor. When condensate is used as cooling medium for oil, there is a danger of oil leaking into condensate, which is likely to cause trouble with the boiler tubes.

New York City. L. J. LEVIT.

Taking the Loop Out of the Diagram

Some years ago I took charge of a plant in which there was installed a low-pressure turbine to take steam from a 30x60x54-in. cross-compound Corliss engine that had previously operated condensing.

An exhaust line had been run from the engine to the turbine that was smaller than the exhaust outlet from the low-pressure cylinder. This caused the back pressure to be so high that we could get very little



Balanced valve controlling high-pressure steam to receiver operated from governor cross-shaft

power out of the low-pressure cylinder, the diagram having at times a loop representing negative work almost as great as the remainder of the diagram.

The turbine was supposed to carry full load with 3 lb. gage inlet pressure, but to secure this the back pressure on the engine would rise to between 5 and 8 lb. To add to the difficulty the high-pressure cylinder had been bushed, thus reducing it to 28 in., which made it impossible to get enough steam through it to supply the low-pressure cylinder.

In an endeavor to overcome the trouble I had a 3-in. line run from the main steam header to the receiver. A 3-in. balanced lever valve was put in the line and placed under the cross-shaft of the governor as shown in the sketch.

On the valve lever was a plate *A*, carrying a trigger releasing device consisting of the small lever *B*, the bell-crank trigger *C*, and spring *D*. To the lever *B* a light chain was connected, the other end fastening to the lever on the governor cross-shaft. For tripping the latch *C*, a stop made from two pieces of iron *E* and *F* was bolted to the valve flange, the piece *F* being made adjustable.

The device was so adjusted that when the governor was in its lowest running plane or "on the pin," the 3-in. valve would be wide open. In this position the trigger *C* would almost touch the stationary piece *F*. In case the governor should drop low enough to operate the safety cams on the high-pressure valve gear, the trigger *C* would then strike the stop *F*. This would release the lever *B* and the weight on the lever would close the valve, shutting off the high-pressure steam to the receiver.

When the governor approached its highest plane, the valve would be entirely closed owing to the rotation of the governor cross-shaft allowing the weighted lever to take a lower position.

With this arrangement we were able to take the negative loop out of the diagram and pull the increased load on the engine and turbine. JOSEPH STEWART.

Hamilton, Ohio.

The Extra Ten Feet

A successful well usually means quantity and quality of the water obtained. And yet these two items, important as they are, do not tell the whole story.

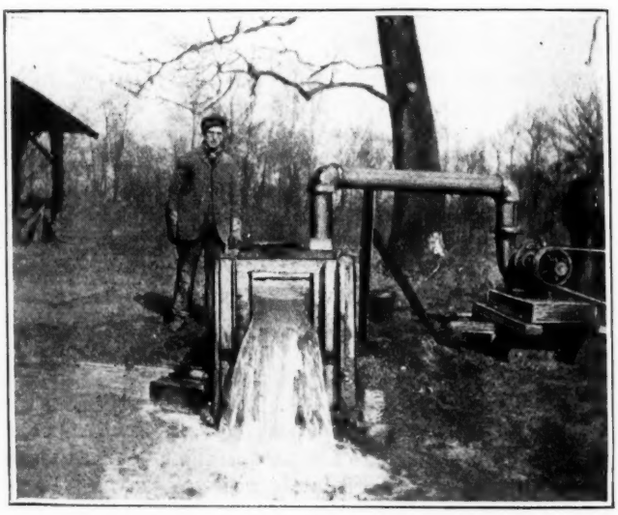
Every so often I am called into consultation where some one, tired of multiplicity of wells and suction troubles, has made a contract for a large-diameter well, which carried a bonus and penalty clause for all water over or under a certain capacity.

Not infrequently the drillers let the well go at the amount specified. But when they have spent extra money to be sure of the capacity, they collect for every gallon pumped, which bill often worries the owner.

The contract is definite. It protects the driller. The owner has compared it with direct suction tubular wells, where both types are possible, and makes his decision as to relative cost. But here is one item he failed to compute.

Take, for example, a contract for 1,000-gal. a minute, with 1,400 gal. secured with a bonus of $5 a gal. for the extra 400 gal. Under the former suction conditions with small wells, the lift was 16 ft. Under the new conditions, with the submerged pump, the "relative" lift was 36 ft., or even more. The efficiency of the submerged pump is some 50 per cent. Now see what happens.

The extra 20 ft. on 1,400 gal. will require an additional 11 kw.-hr. At 1.5c. a kw.-hr. this means a



Weir measurement determines drillers' bonus

power bill of $3.96 a day, or $1,188 a year on a 300-day basis. At 6 per cent this represents the interest on far more than the cost of the well, and payment will be required as long as the full capacity is pumped.

In certain territories large wells and vertical pumps are not only desirable but necessary. In other cases either type is possible. In all cases there is a balance between cost of installation and increased cost of pumping, which must be considered.

Dayton, Ohio. COLLINS WIGHT.

Comments from Readers

Orsat Kinks

The photographs (in the March 31 issue) of Mr. de Graaf's arrangement for replacing the gas bags of the absorption pipettes of an Orsat apparatus with a water seal are interesting. While the idea is not new, the arrangement, particularly the vertical manifold with the long bent tubes, is ingenious as it allows ample flexibility to remove and replace individual pipette connections without straining the other joints and causing annoying leaks. We have found that the CO_2 pipette suffers little by not being connected to the water seal, as absorption of CO_2 from the atmosphere is slow and if the Orsat is used only at considerable intervals the rear opening may be stoppered when not in use. Leaving this connection open gives noticeably quicker action in pumping gas back and forth between burette and absorption pipette and allows of obtaining results for checking observation of fire conditions with the least possible delay.

The photographs show a form of apparatus developed (I understand) at Ohio State University. This has proved satisfactory in traveling work, as it allows samples to be obtained direct from the flue with a minimum chance of contamination. The rubber tube shown connects to the gas sampling tube of the boiler —$\frac{3}{16}$-in. or $\frac{1}{4}$-in. 20-gage seamless copper tube such as is used for gasoline and oil-feed lines, is convenient as it is light, coils readily, will not burn and is obtainable in lengths up to 30 ft. without containing an excessive volume to be exhausted.

When a sample is to be taken, the line is cleared by exhausting with the rubber bulb *D*, which sucks the gas down through the lower leg of the glass inlet tee *B* through the rubber Bunsen valve and the water seal of the small bottle *C*. This prevents any air being drawn back to dilute the sample even if the aspirating-bulb valves do not hold.

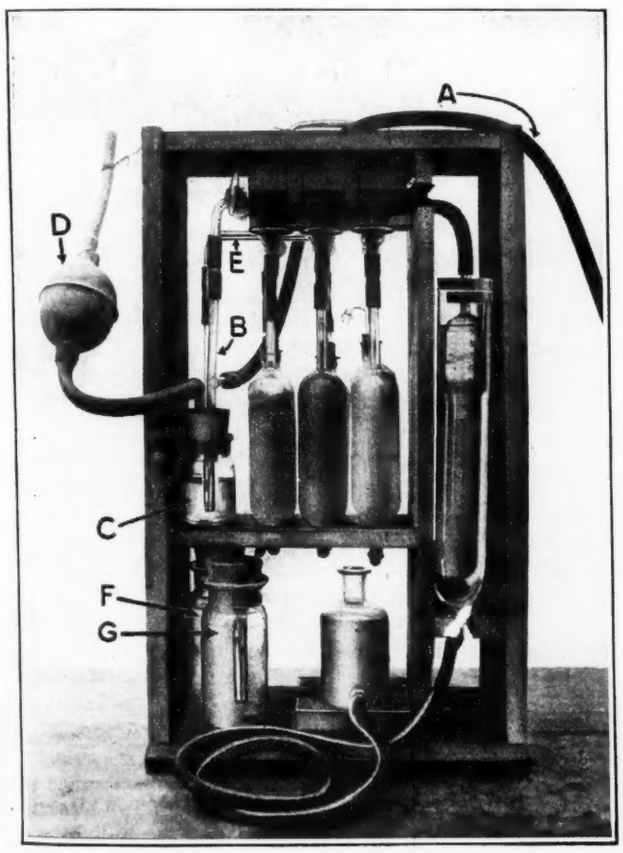


Fig. 1—Front view of Orsat

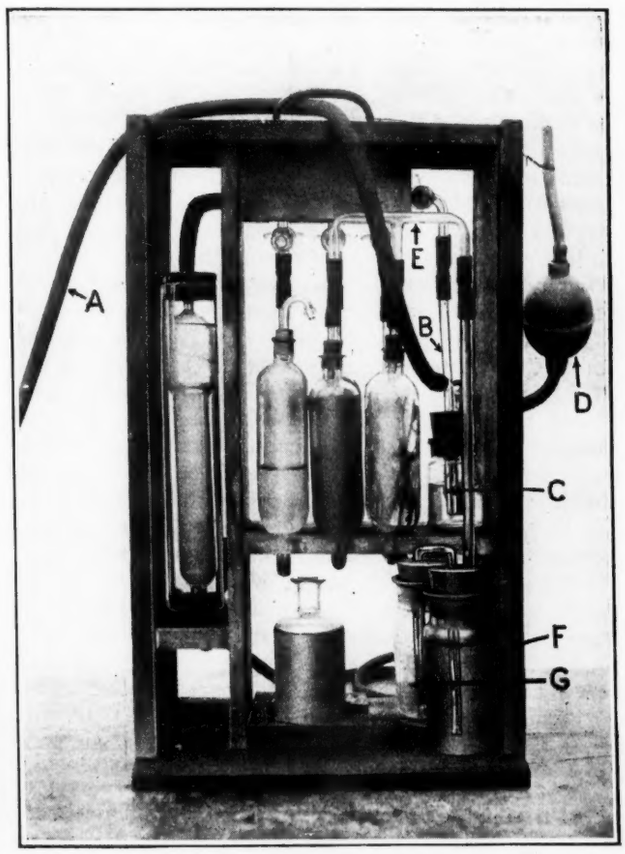


Fig. 2—Rear view of Orsat

At the same time gas is drawn into the burette by turning the three-way cock and lowering the leveling bottle, so as to flush out the capillary manifold, etc., with fresh gas. This is rejected through the rear outlet of the three-way cock. The operation should usually be repeated three times to insure against any dilution from a residue of dead gas. The advantage of this form of sampler is that the sample to be analyzed is not subjected to errors caused by bubbling it through water and, owing to the comparatively small amount of

dead gas in the capillary tubing, this can be much more quickly and readily cleared than in those forms where all the gas to clear the sampling tube is pumped through the manifold and measuring burette.

Use over considerable periods has shown that cotton-wool filters are of comparatively little use, as if no excess of grease is used on stopcocks, any soot found will pass into the solutions and not accumulate in the necks of the pipettes or manifold. The two bottles *F* and *G* on the lower shelf of the Orsat form a water seal for the rear chambers of the pipettes through the manifold *E*.[1]

The water of the measuring burette should be colored with methyl orange and a few drops of sulphuric acid. This not only gives it a red color which is more easily visible, but if by any accident a little potash is splashed over into it, which would give erratic results by absorbing part of the CO_2 during sampling, the change of color to orange will immediately call attention to it.

In measuring the sample before analysis, it is much easier to obtain an exact 50 or 100 c.c. by placing the gas in the burette under a slight pressure, pinching the leveling bottle tube near the bottom of the burette, setting the leveling bottle on top the Orsat case, opening the three-way cock to atmosphere and allowing water to flow in until the meniscus stands just at zero. If the gas is compressed until the meniscus stands just at zero and the pressure released, the equalization of pressure, particularly with a little water in the manifold, is always slow and the sample usually measures 0.1 or 0.2 per cent over 100 in volume.

A handy check on the accuracy of analyses is, with the usual run of Eastern coals, to subtract one-sixth the percentage of CO_2 from 20.9, which should give the sum of CO_2, O_2 and CO if there is not too much of the last. For fuel oil one-third the CO_2 percentage should be used and, in general, the combustion engineer can figure his own factor, according to the carbon-hydrogen ratio of the coal. It is a simple check to apply and prevents waste of time running a long series of analyses with leaky apparatus or spent solutions. It will not, however, indicate air leakage into the sample before it is measured at the beginning of an analysis.

And, lastly, in case of uncertainty, one should not forget that the atmosphere constitutes an unlimited supply of a standard composition gas for checking purposes and that, until the user and apparatus can analyze this correctly, they are wasting time on flue gas.

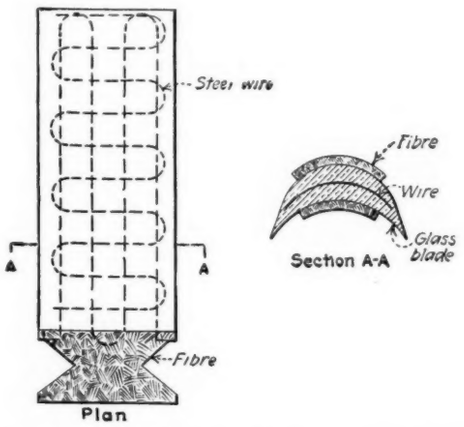
New Haven, Conn. H. D. FISHER.

Hardness Desirable in Steam-Turbine Blades

With interest I note the discussion in *Power* of March 31, both editorially and by special article, of the matter of erosion and corrosion of turbine blades, such as are at present manufactured, and should like herewith to present a suggestion.

This matter of corrosion is especially noticeable as a result of steam action upon blades of the low-pressure stages, and is presumably due to a small content of actual water. This seems possible to be eliminated more cheaply in these low-pressure, low-temperature, and high-velocity stages by using glass vanes molded with wire mesh instead of machined chrome-nickel steel blades. These may be of such a quality as would stand slight grinding or shaping if necessary, although such a requirement is not probable. The glass blades could be intermeshed in the fastenings with fiber strips about 0.03 in. thick, thus eliminating vibration or lost motion, as shown in the figure.

The wire mesh, embedded as near the impact face as possible, say one-eighth inch, is chiefly to avoid general fragmentary dissipation should fracture occur. By being near the impact face, steel will give the added tensile strength there needed. Concerning the matter of erosion it seems that glass will adequately stand



Suggested reinforcing and fiber-protected root for turbine blade of glass to resist corrosion

such test unless the steam is contaminated with solid foreign matter. Glass may be used only in these low-temperature stages where, owing to the water content, corrosion is frequently the maximum. E. I. BAKER.

Cambridge, Mass.

[The idea of glass as a material for turbine blading which is likely at times to be subjected to vibration, rubbing and possibly the impact of foreign solid substances, would not appeal to many operating men. In connection with this suggestion, however, it should be pointed out that steam temperatures eventually may advance beyond the range of the present available materials, and that elements other than iron are now thought by some to be more adaptable as bases for compositions to resist such extreme conditions. Materials of the vitreous or refractory type are not improbable for high-temperature blading, particularly in possible developments of the gas turbine. Greater resistance to corrosion, as the author points out, may render glass or vitreous material desirable for special applications at low temperatures.—EDITOR.]

Although the operation of a pulverized-coal fired boiler at a practically uniform CO_2 is comparatively simple compared with some other methods of firing it is already possible to find operation of these boilers back in the old trail and running along anywhere between 8 and 12 per cent, presumably to lengthen the life of the tubes and refractories, while at the same time the same boiler during the first year or so was operated around 15 per cent CO_2 without any apparent depreciation to either.

[1] This arrangement is equivalent to that described by Mr. de Graaf.

Questions and Answers

Conducted by

Franklin Van Winkle

Foaming and Priming

What is the difference between foaming and priming of a boiler? *P. V. B.*

Foam in a boiler consists of unbroken bubbles of steam caused by impurities that are dissolved in the water or carried in suspension. As the impurities become more concentrated, foaming increases, frequently filling the whole steam space. Scum caused by oil, vegetable matter or sewage collected on the surface of the water frequently is a cause of foaming, as the bubbles of steam in rising through the scum form foam. Priming consists of carrying water from the boiler by the steam when the water is suspended in the form of a mist or foam or as moisture swept out of the boiler by the high velocity of the steam. Hence priming may occur when there is rapid disengagement of steam from a small area of water surface, from sudden release of large quantities of steam, from carrying a high water level, from forcing the boiler or from foaming of the boiler.

Boiler Corrosion from Good Water

Our water supply is considered to be of good quality for general purposes, and as boiler-feed water is free from scale-forming impurities, but there is pitting and corrosion in parts of the boilers. What may be the cause and remedy? *H. W. A.*

If corrosion is at or above the water line, it is likely that the water is highly aërated. Corrosion below water line usually is due to the presence of an acid in the water. A small quantity of soda ash in the feed water may be beneficial. Another method of arresting corrosion below the water line would be to place only enough lime in the boilers to form a whitewash coating so thin that it would not endanger burning the boilers or materially affect the economy of the boilers and coat the surfaces above the water line with a thin lime wash.

Cause of Compressor's Low Temperature

Of late one of my ammonia compressors has been acting strangely. When starting up, the back pressure goes down to 5 lb., and after an hour's run it comes up to 10 lb. and stays there. Opening the expansion valve will not bring up the back pressure. The receiver holds 800 lb. of liquid ammonia and we charge it with 400 lb. After the machine has run 20 hours, the discharge is stone cold and the suction becomes frosted way back over the jacket. What causes this and what is the remedy? *W. P. S.*

The cold discharge pipe is due to a considerable amount of liquid ammonia entering the compressor. The evaporation of this liquid during compression serves to keep the temperature at a low value. To cure this, a separator may be placed in the suction line to catch the liquid, or more coils should be used. The reason the suction pressure drops to 5 lb. gage when starting and then rises to 10 lb., is that upon starting the compressor is handling only ammonia vapor and has a capacity sufficient to draw off the vapor as fast as it forms. After a short time the liquid begins to come over, and as much of it vaporizes in the cylinder on the suction stroke, the compressor's capacity is reduced and consequently the machine cannot handle the vapor as fast as it is formed, and the pressure rises.

Size of Header for Battery of Boilers

How is the size determined for the steam header for a battery of boilers? *L. D.*

The size of header depends on the boiler pressure, quantity of steam to be delivered per minute, permissible drop in pressure between the boilers and point of delivery and length of steam pipe, based on the lowest probable boiler pressure and lowest permissible steam pressure at the point of delivery.

The Babcock formula for the flow of steam in pipes is:

$$W = 87\sqrt{\frac{w(p_1 - p_2)d^5}{L(1 + \frac{3.6}{d}}}$$

in which

W = Weight of steam flowing per minute;
w = Mean density of the steam, pounds per cubic foot;
p_1 = Pressure, pounds per square inch at entrance;
p_2 = Pressure, pounds per square inch at point of delivery;
d = Diameter of pipe in inches;
L = Length of pipe in feet.

Substituting the given values in the formula and solving for d gives the required pipe diameter.

Friction of Steam Engine Practically Constant

In determining from indicator diagrams the power required of a non-condensing engine for driving a generator in the development of different electrical loads, what allowance should be made for variable friction of the engine? *H. M. A.*

The friction of a steam engine is sensibly constant at any given speed at all loads. However, the engine friction increases with increase of its speed and also with increase of the steam pressure. Indicator diagrams for determining engine friction should be taken under the same conditions of lubrication and adjustment as when loaded and when the engine is run unloaded and runs at the regular speed, care being taken that the speed is uniform and identical with the speed obtained when diagrams were taken with the different loads, and with the regular steam pressure

throttled no more than necessary for holding the engine down to the regular speed. When the speed and pressure conditions are established, the diagrams taken for determining engine friction should be uniform in form and power value and diagrams obtained under different conditions should be discarded. When a number of friction diagrams have been taken under correct conditions, the value of each should be the result of averaging three measurements. The average of these averages will give the engine friction under the loaded conditions well within the personal error of measurement of the diagram. Then the net power chargeable to any load will be the average of several diagrams minus the engine friction.

Setting D Slide Valve Without Uncovering Steam Chest

How can a D-slide valve or piston valve be set without removing the steam-chest cover? *L. R. D.*

If there is a rocker for transmitting motion from the eccentric rod to the valve rod, the length of the eccentric rod should be so adjusted that the rocker arm will swing approximately as far to one side as the other of that position which would be at right angles with the valve rod. When the eccentric rod length has been thus adjusted, the valve setting should be completed with the valve-rod length so adjusted that one end of the valve will travel as far over the opening edge of its port as the other end, after which the eccentric may be set to give the desired amount of lead.

If the valve-stem length cannot be adjusted without opening the steam chest, and the middle position of the rocker would be thrown only slightly out of perpendicular with the valve stem by adjusting the length of the eccentric rod, then a fair valve setting can be obtained by adjustment of the eccentric rod length in place of the valve-stem length for obtaining equal travel of each end of the valve over the opening edges of the ports.

For testing the equalization of the valve travel, place the engine on a dead center, make a mark on the guide to correspond with a mark on the crosshead, and set the eccentric on the shaft to that position which will just permit steam to be blown through the port at the same end of the cylinder by turning the eccentric forward on the shaft. Then turn the engine wheel forward to the position where by opening the throttle a little, steam is shown by the pet-cock to be admitted to the other end of the cylinder. If admission occurs at the end of the stroke, equalization is complete; but if admission is not at the end of the stroke note whether admission occurs before or after the crank comes up into dead center. With the crosshead standing at this point, make a mark on the guide to correspond with the mark on the crosshead; also when the engine is on dead center at the same end of the stroke.

Then make a mark on the guide halfway between the marks last made on the guide, and block the engine wheel to such a position that the mark on the crosshead will be opposite to this middle mark and adjust the length of the valve rod or eccentric rod so steam will be just admitted to the corresponding end of the cylinder.

Next turn the engine forward toward the other dead center until the mark on the crosshead comes the same distance from the end of the stroke before or after the completion of the stroke, as found for the middle mark at the other end of the stroke. If steam is just admitted, the travel has been equalized. If not, turn the engine to the position where steam is just admitted, make another mark on the guide halfway between the position where the steam was admitted and the position where it should have been admitted, and with the crosshead set at this middle mark, readjust the valve-rod or eccentric-rod length until steam is just admitted. With the valve travel thus equalized, place the engine on the head-end center, turn the eccentric forward and set it to the position at which steam is just admitted to the head end of the cylinder. Then make a mark on the valve rod at the end of the valve-rod stuffing-box gland and set the eccentric as much farther forward as may be necessary to draw this mark away from the stuffing-box gland a distance equal to the desired amount of lead.

Changing from Two-Wire to Three-Wire System

We changed our lighting system from two-wire 120 volts to three-wire 120 and 240 volts. The meter connection on the old system is shown in Fig. 1 and for the new in Fig. 2. The current transformer was changed, but the same meter was used. Should the meter reading be multiplied by two to give the correct kilowatt-hours? *F. E. C.*

With either one of the connections shown in the diagrams the meter will record the kilowatt-hours transmitted in the circuit. On the three-wire circuit the full capacity of the meter will be reached at 300-ampere load, where in the two-wire circuit the load can be 600 amperes before the full capacity of the meter is reached. In the three-wire circuit a current transformer is used with two primary windings, one of these windings being connected in each of the two outside legs of the circuit. The effect of the primary windings is added up in the secondary. For example, 80 amperes in each of the outside legs of the circuit, Fig. 2—that is, through each of the primary windings—would have the same effect in the secondary as 160 amperes flowing in one winding only. With a transformer ratio of 160 to 1, as in this instance, one ampere would flow in the secondary winding in each case. For this reason the meter will read the watts transmitted in the circuit directly, and no multiplier is required. But as stated, the meter will take care of only a 300-ampere load on the three-wire circuit, which is equivalent to the same number of kilowatts as 600 amperes on the two-wire circuit.

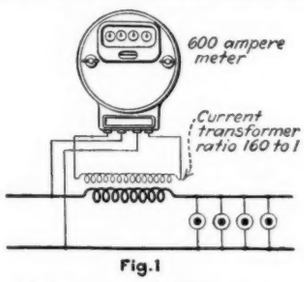


Fig.1

Meter connections for two-wire 120 volts

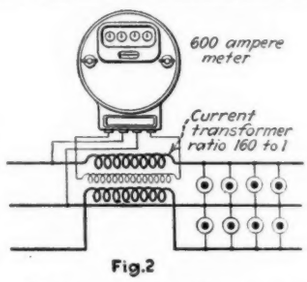


Fig.2

Meter connections for three-wire 120 and 240 volts

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communication and for the inquiries to receive attention.—EDITOR.]

A new slant on things observed in and out of the power plant

What Happens and Why?

What One Pound of Coal Could Do

WHEN a man lifts a 100-lb. weight several feet or hoes the garden on a Saturday afternoon, he figures that he has used up a considerable quantity of energy. When a heavy steel girder is suspended high above the street, one thinks of the tremendous amount of potential energy stored in the metal. Yet, all these quantities of energy are negligible in size compared with that stored in a single pound of coal. The energy consumed in lifting a 100-lb. weight five feet is 500 ft.-lb. Taking the "m.e.p." on the hoe handle at 10 lb. (subject to corretion by gardening enthusiasts) and the "piston speed" (based on the working stroke only) as 2 ft. per sec., the energy delivered by the worker is 20 ft.-lb. per sec., 1,200 per min., 72,000 per hour, and 360,000 in five hours.

The steel girder, let us say, weighs 10 tons and is poised 100 ft. above the street. Its potential energy is then 2,000,000 ft.-lb.

Now let us see how much energy is locked up in a pound of average coal, leaving out of consideration the fact that there is no known way of turning all this energy into mechanical work. A fair value for the heat content of a pound of average coal would be 13,500 B.t.u. Since each B.t.u. is equivalent to 778 ft.-lb., this gives an energy content of 10,500,000 ft.-lb., or about five times that stored up in the girder. The latter therefore represents the energy in about three ounces of coal.

Imagine a mountain a mile high, as outlined in Fig. 1, and a ton of coal lifted that vertical distance. The total work accomplished would be the product of the height, 5,280 ft., by the weight lifted, 2,000 lb., giving a result almost exactly equal to the energy in one pound of coal.

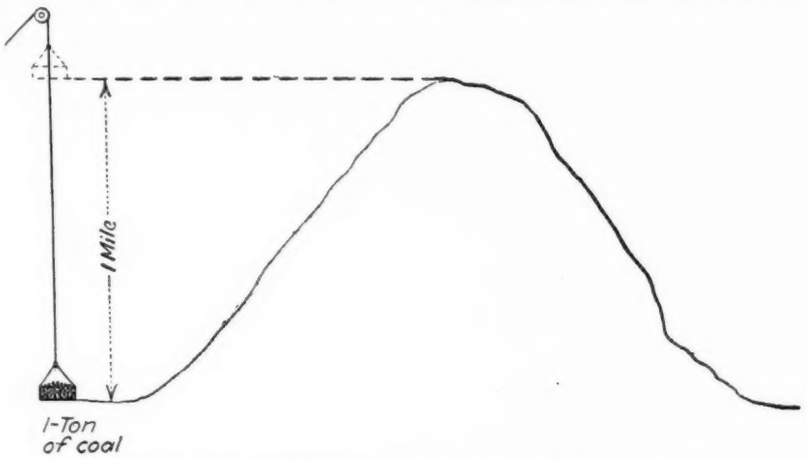


Fig. 1—The energy in one pound of coal would lift a ton to the top of a mountain one-mile high

Perhaps an even more striking comparison may be drawn from the field of heavy artillery. From the formula for kinetic energy it can easily be figured that a 100-lb. projectile would have to move with a velocity of 2,600 ft. per sec. (about thirty miles a minute) to contain 10,500,000 ft.-lb. of energy. Fig. 2 pictures an imaginary gun, designed to deliver all the energy in a pound of coal to such a projectile. The gun is elevated at an angle of 45 deg. Leaving air resistance out of consideration, the projectile would rise to a maximum height of 10 miles, and land at a point 40 miles from the gun.

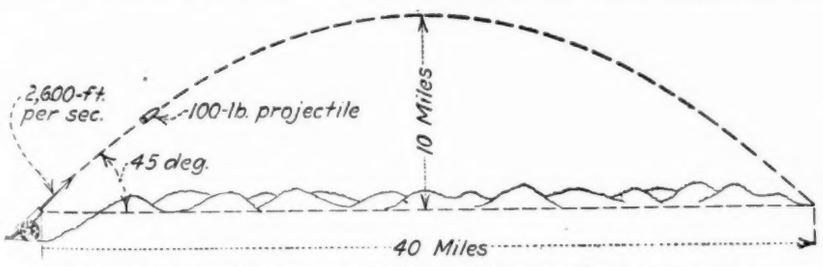


Fig. 2—It would throw a 100-lb. projectile 40 miles in a vacuum

As another illustration, take the case of a 40-watt light (Fig. 3). One watt is equal to 3.412 B.t.u. per hour, so that 40 watts would amount to 136.5 B.t.u.

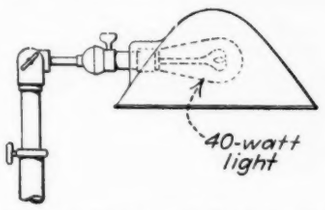


Fig. 3—Forty-watt light would burn 100 hours

Evidently, the 13,500 B.t.u. in 1 lb. of coal, if applied without loss, could run this lamp nearly one hundred hours.

A typical use of energy is for the pumping of water. Imagine a centrifugal pump raising water to a tank elevated 100 ft. above the source. Allowing 8⅓ lb. per gal., it is a simple matter to show that the energy in one pound of coal would be sufficient to pump 12,600 gal. against this head.

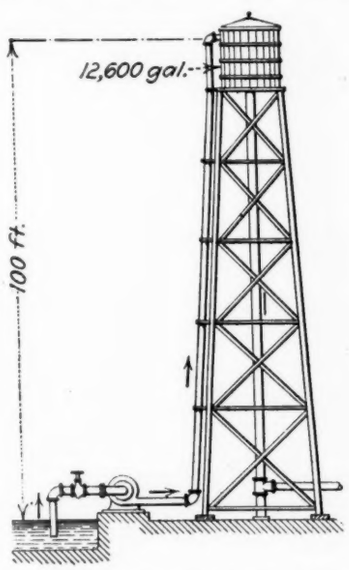


Fig. 4—Pump would raise 12,600 gal. 100 ft.

These illustrations are sufficient to give a picture of the tremendous amount of energy locked up in coal. For use as heat from 70 to 80 per cent of this energy can now be released by commercial apparatus. For the performance of mechanical work or the production of electricity the best results now obtained are much poorer than this. At the present time 20 per cent is a high figure.

The Rational Design of Covering for Pipes Carrying Steam Up to 800 Deg. F.*

ENGINEERING publications known to the authors contain no rational method of determining the correct thickness of covering to be placed on pipe carrying steam and hot water. The method here shown was worked out in the process of determining the economic thickness of heat insulation for pipe in a recently built large central station.

Two cases were considered. In the first a single insulating material was used, while in the second case[1] it was considered necessary to use a material of higher heat-resisting properties between the pipe and the same kind of material used in the first case, on account of the excessive steam temperature.

This analysis considered only a 6-in. pipe surrounded by air at 80 deg. F. The cost of the heat in the steam was taken as 35 cents per million B.t.u.'s. In Case 1 the total temperature of the superheated steam was 500 deg.

Small Temperature Differences Neglected

It was assumed in all cases that the outside temperature of the pipe was the same as that of the superheated steam. This assumption involves a slight error in the case of bare pipe and a negligible error with covered pipe. It was also assumed without serious error that the temperature of the inside surface of the pipe covering was equal to the temperature of the pipe.

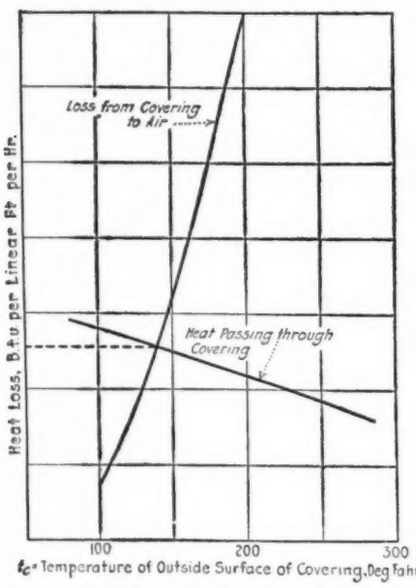

Loss from Covering to Air
Heat Passing through Covering
Heat Loss, B.t.u. per Linear Ft. per Hr.
100
200
300
t_c = Temperature of Outside Surface of Covering, Deg. Fahr.

Fig. 1—Heat lost through 1½-in. covering on a 6-in. pipe.

The loss per running foot of bared pipe was obtained from curves published by R. H. Heilman, based on his work at the Mellon Institute. From Heilman's analysis the following equation was derived for the heat loss from the canvas surface per running foot of the pipe:

$$h_2 = \frac{147.6D^{0.81}\ (t_c - t_a)}{272.5 - (t_c - t_a)}$$

In the foregoing formula h_2 equals B.t.u. loss from the canvas surface per linear foot of pipe; D equals diameter of canvas surface in inches; t_c equals temperature of the canvas-surface in deg. F.; t_a equals temperature of surrounding air in deg. F.

The following is a similar equation for the heat passing through the layer of pipe covering:

$$h_1 = \frac{0.524K\ (t_p - t_c)}{\log_e \frac{r_c}{r_p}}$$

In this equation K = mean absolute thermal conductivity of the insulating material in B.t.u. per sq.ft. per hour per inch of thickness per degree *F.*

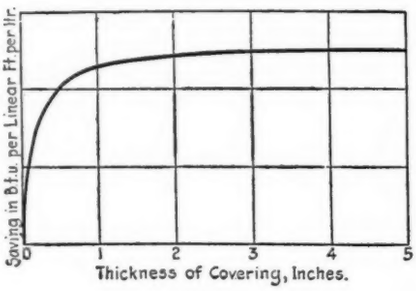


Fig. 2—B.t.u. saving resulting from various thicknesses of pipe covering on a 6-in. pipe carrying steam at 500 deg. F.

t_p = pipe temperature; t_c = temperature of outside surface of covering;

r_c = outside radius, inches;

r_p = outside pipe radius, inches.

Now it is evident that after steady conditions have been established the heat passing through the covering must be equal to that passing through the canvas. These two equations were therefore solved for various values of the temperature of the outside surface of the covering and the resulting curve plotted as shown in Fig. 1. The intersection of the two curves gives the point at which the heat loss from the canvas is equal to the heat passing through the covering. This point therefore represents the actual heat loss.

Method of Figuring the Net Saving

Heat losses were obtained in this manner for several thicknesses of covering. Subtracting these from the bare pipe loss gave the corresponding savings, which are plotted in Fig. 2. Actual numerical values are omitted, since it is only desired to show the method. It should be noted that this curve is for a single pipe size and a single steam temperature.

The gross monetary saving was easily figured from the assumed heat cost of 35 cents per million B.t.u., the result being plotted as the top curve in Fig. 3.

To get the net monetary saving it was necessary to deduct the fixed charges, which naturally increase with the thickness and cost of the insulation. The fixed charges on the covering, including maintenance, depreciation, interest and taxes, were taken as 20 per cent of the cost of the covering. The latter included the purchase price per linear foot of the covering, plus freight charges and the labor of installation. The cost of labor was based on estimates supplied by two nationally known companies that manufactured pipe covering and applied it under contract.

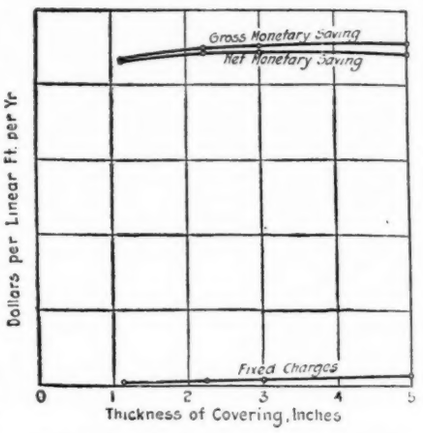


Fig. 3—Curves used in selecting the most economical thickness of covering for a 6-in. pipe carrying steam at 500 deg. F.

Net Saving Little Affected by Thickness

The resulting fixed charges are plotted as the lowest curve on Fig. 3. Subtracting the values shown by the lowest curve from those shown in the top curve gives the middle curve of net monetary saving. Two things stand out about this curve. The first is that by far the larger part of the total saving is net saving. The second is that the curve is very flat, allowing a wide choice in the thickness with little effect on the net saving. A thickness of three inches seemed to be about best for the case considered. This thickness was chosen in the form of two layers each 1½ in. thick.

Western Louisiana Project—Wellman Bradford, on behalf of the Louisiana Gravity Canal Co., has applied for a license covering an extensive irrigation and power project on the Calcasieu River and Bayou Cocoderie, in western Louisiana. The applicant held a preliminary permit covering this project for eighteen months and allowed it to elapse six months ago. Mr. Bradford was not in a position at that time to apply for a license. He now advises the Commission that he is ready to proceed with the project.

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*Abstract of a paper to be presented by W. A. Carter and E. T. Cope, of the Detroit Edison Company, at the Milwaukee spring meeting (May 18-21, 1925) of the American Society of Mechanical Engineers.

[1]On account of lack of space only the first case is covered in this abstract.

Tests of a Unaflow Engine*

By George H. Barrus

A SERIES of tests have been conducted by the author on a four-cylinder vertical unaflow engine, non-condensing, direct connected to a 400-kw. alternating-current Burke generator. The tests were conducted for the Great Western Laundry Co., of Chicago, making use of the testing plant of the Amos Iron Works, Oswego, N. Y., which designed and built the engine.

Both cylinders and heads are steam jacketed, the cylinder jackets extending around a belt at both top and bottom of the casting with openings leading to the jacket spaces in each head. The steam on its way to the steam chest passes through the jackets, and the condensate, if any, is free to drop into the bottom heads, whence it is discharged through a mechanical trap. Except at very small loads the sweep of the steam keeps the condensate in motion, and the trap rarely discharges either water or steam.

Steam Volumes

The cylinders are arranged in two pairs, with cranks 90 deg. apart. Two cylinderfuls of steam are thus withdrawn from the source of supply at each quarter of a revolution. The volume of piston displacement at, say, one-quarter cutoff is 0.71 cu.ft., that of the entire jacket spaces and steam chests is 8.2 cu.ft., and that of the throttle valve and piping from the cylinder flange to the stop valve on the steam drum is 2.0 cu.ft. These volumes are specially noted for the purpose of comparing the amount of steam withdrawn from the storage spaces at each double steam admission, this being about one-twelfth of the jacket volume.

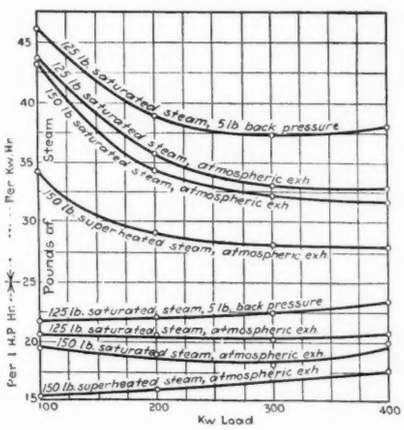
It was noticeable that the fluctuations of steam pressure at the throttle valve were extremely small—indeed, the cock on the steam gage at the throttle was kept wide open and the gage pointer vibrated not more than its own width. The steam-pipe diagrams taken at the throttle valve revealed the same substantial absence of fluctuations, being practically a straight line. These results are obviously brought about by the influence of the multiple cylinders and the storage spaces of the jackets. Absence of pressure variation in the steam main, in its practical aspects, contributes not only to steam economy, but to structural advantages as well, for it makes the pipe itself secure with a minimum amount of anchorage and, further, enables the size of the pipe to be reduced to its smallest practicable diameter. The velocity of the steam in the pipe at the greatest load was estimated at 108 ft. per sec.

The admission valves are double-beat poppets, lifted vertically by a horizontal camshaft. This shaft is moved laterally by a horizontal centrifugal spring-resisted governor, which varies the cutoff according to the lateral position of the cams.

The moving parts of the engine are shut in by a casing, and no adjustment from the outside can be made while in operation, except to vary the speed by tightening or loosening the governor spring. This construction admits of the use of a pressure oiling system for the lubrication of the entire engine.

The apparatus for measuring the steam consumption as used here, consists of a surface condenser of ample capacity placed below the level of the engine and discharging by gravity into a pair of weighing tanks.

The tests were carried out in a continuous series for each set of conditions, starting with the light load, then changing to the next load, and so on, or vice versa. The current from the generator was absorbed by a water rheostat, and the load was maintained constantly at the desired point by hand regulation at the switchboard or rheostat terminals.



Steam consumption of vertical unaflow engines

The dimensions of the engine are given in Table I.

TABLE I—ENGINE DIMENSIONS

Number of cylinders	4
Dia. of cylinders, in.	14
Dia. of piston rod, in.	2⅜
Stroke, in.	16
Revolutions per minute	300
Clearance volume in per cent of piston displacement, as calculated from drawing first and second series, per cent	22
Clearance volume calculated for third and fourth series, per cent	17
Inside dia. of steam pipe, in.	4.8
Inside diameter of each of the two exhaust pipes, in.	8

The four series of tests, each with the four loads noted, were:

1st series—Saturated steam, 125 lb. pressure, atmospheric exhaust.

2nd series—Saturated steam, 125 lb. pressure, 5 lb. back pressure.

3rd series—Saturated steam, 150 lb. pressure, atmospheric exhaust.

4th series—Superheated steam, 150 lb. pressure, atmospheric exhaust.

The steam on all the saturated steam tests was practically dry steam, a throttling calorimeter showing almost constantly a temperature of 277 deg. F. with 125 lb. pressure at the throttle valve, indicating a moisture of less than one-half of one per cent. No correction was made for this small amount.

When using superheated steam, the total steam temperatures were: Full load, 437 deg. F.; ¾ load, 427 deg.; ½ load, 443 deg.; ¼ load, 469 deg. F.

The indicated horsepower was determined by taking diagrams and kilowatt readings simultaneously, and correcting for any departure from the even loads at which the averages were continuously maintained. The horsepowers should be slightly reduced owing to the error of the three-way indicator cocks. This error, however, was practically offset by a corresponding error due to the reducing motion in use, which acted the opposite way, and these errors may be disregarded.

Test Results

The economy results of the various tests are shown graphically by the curves in the illustration, in which horizontal distances represent the loads in kilowatts and vertical distances pounds of steam consumed per indicated horsepower-hour and per kilowatt-hour. In each case a curve is drawn showing what may be considered the average curve of performance. It is interesting to note the effect that superheating produced on the curve of that series as compared with that given with saturated steam; the superheated curve is substantially a straight line.

In connection with the operation of the unaflow principle in this engine, the question of cylinder condensation comes to the front. Table II shows the steam accounted for by diagram in one of the series of tests with saturated steam as well as the proportion this bears to the actual steam consumption.

TABLE II—STEAM ACCOUNTED FOR BY DIAGRAM

Load, kw.	100	200	300	400
Apparent cutoff percentage, per cent	4.1	7.8	10.2	16.9
Steam accounted for by diagrams per i.hp.-hour, lb.	13.72	16.19	17.75	18.2
Actual steam consumed per i.hp.-hour, lb.	20.6	20.4	20.1	20.7
Percentage accounted for	66.6	79.4	88.3	88.0

At the close of the second series of tests the admission valves were tested for leakage under a standing pressure, with engine blocked, the steam that leaked being revealed by escape into the air through the indicator piping. There was practically no leakage. When the throttle valve was shut and the steam was retained in the steam chests, the pressure within dropped at the extremely low rate of 5 lb. per min., requiring ten minutes time to be reduced from 120 lb. to 70 lb.

In his capacity as acting chairman of the Federal Power Commission, Secretary Work has increased the salary of O. C. Merrill, the Commission's Executive Secretary, from $6,000 to $7,500. Because of the limitation carried in the appropriation acts that become operative July 1, it will be necessary to reduce the salary to $6,500 after that date.

While Mr. Merrill states that he is highly appreciative of this recognition, it will not alter his determination to take a vacation and look for a job where the remuneration is likely to be more nearly commensurate with his experience.

*Extract of paper presented before the Spring Meeting of the American Society of Mechanical Engineers, Milwaukee, Wis., May 20, 1925.

Comparative Performance of Stations

Heat Consumption per Unit of Output Shows Steady Improvement in Four Well-Known Plants

WHILE the heat rate of a central station in B.t.u. per kilowatt-hour by no means tells the whole story as to its commercial economy, it is a figure of considerable interest.

Among the large central stations for which heat-rate data are now available are Colfax, Lakeside, Cahokia and Philo.

COLFAX

Colfax,[1] the oldest station in the group, went on the line in December, 1920. Since then the plant has been twice extended. The first addition (1922) was 60,000 kw.; the second (1924) 70,000 kw. The third extension, authorized last fall, will add 80,000 kw. The plant capacity to date is 190,000 kw. and in 1926-27 it will be 270,000 kw.

The Colfax steam pressure is 265 lb. at the throttle and the total temperature is 600 deg. F. The first two units had no flue-gas heat reclamation. With the last extension of the station about 35 per cent of the plant boiler capacity has been equipped with air heaters.

The average coal consumption per kilowatt-hour output on the line for each year of operation is given here (the figures in parentheses are the corresponding B.t.u. consumptions based on an average heat value for the coal used of 13,000 B.t.u.). The coal rate for the system of the Duquesne Light Co. for each year is also shown. These system figures take into account all the power distributed from the various generating stations of the Duquesne Light Co., and their improvement during the five-year period is explained by the performance of Colfax and the skillful methods of system operation employed to make this station most effective as a base-load plant.

COAL CONSUMPTION PER KILOWATT-HOUR OUTPUT ON LINE

The figures given were obtained by dividing pounds of coal burned by kilowatt-hours output on line—totals for the year.

	Colfax, Lb.	System, Lb.
1921	1.73 (22,490 B.t.u.)	2.23
1922	1.53 (19,890 B.t.u.)	1.98
1923	1.51 (19,630 B.t.u.)	1.82
1924	1.41 (18,330 B.t.u.)	1.65
1925 (first three months)	1.30 (16,900 B.t.u.)	1.58

Lowest weekly coal rate to date—Colfax—March 23-29, 1925—1.28 lb., 16,600 B.t.u.; System — April 13-19, 1925 — 1.50 lb.

The steady improvement year by year in both Colfax and the system coal rates is worthy of note. The marked improvement in the first three months of 1925 may be attributed to the use of powdered fuel, air preheaters, the regenerative cycle and other improvements introduced in the most recent extension of the station. This extension (70,000 kw., made during 1924) has been operating for a period of about six months and is producing power with an average heat rate of 14,600 B.t.u. per kilowatt-hour output on line. This is equivalent to 1.11 lb. per kilowatt-hour of the coal used. Even with these refinements in economy the cost of the Colfax power station per installed kilowatt is remarkably low.

[1]Information supplied through the courtesy of J. M. Graves, vice-president and general manager, Duquesne Light Co., and Dwight P. Robinson & Co., Inc., designers and builders of the plant.

LAKESIDE

The Lakeside station of the Milwaukee Electric Railway & Light Co., one of the first large power plants built for the exclusive use of pulverized fuel, went into operation in 1922. As stated by M. K. Drewry in a paper prepared for the Spring Meeting of the A.S.M.E., the station performance for six months ending with March, 1925, was as follows:

Month	B.t.u. per Kw.-Hr.
October, 1924	16,000
November	15,945
December	16,308
January, 1925	16,066
February	15,861
March	15,930

These figures are net after deducting the energy used in the coal-preparation house, which averaged 1.1 per cent of the station output.

The boilers at Lakeside are provided with economizers but no air heaters. Steam is supplied at 288 lb. and 686 deg. (average from Oct. 10 to Nov. 10, 1924) to the turbines, which operate on the straight Rankine cycle without bleeding. Lakeside is operated as a base-load plant, the load factor for a typical month (Oct. 10 to Nov. 10) being 66.7 per cent. In his paper Mr. Drewry stressed the fact that in the case of a pulverized-fuel station load factor might have less effect upon coal economy than the question of turbine loading.

CAHOKIA

The Cahokia station of the Union Electric Light & Power Co. (St. Louis) is another outstanding pulverized-coal installation. The first 60,000-kw. section of this station went into operation late in 1923. A second 30,000-kw. unit was added in September, 1924. Neither air heaters nor economizers are used at present. The steam conditions are 350 lb. pressure and 700 deg.

Monthly data on this station for the fourteen months ending March 1, 1925, have recently been made available[2] as follows:

Month	B.t.u. per Kw.-Hr., Net	Load Factor	Temperature Condensing Water, Deg. F.
January, 1924	19,310	45.0	32
February	18,694	48	35
March	17,965	65	39
April	17,343	62	53
May	17,408	53	60
June	17,735	55	72
July	17,802	56	76
August	17,951	57	79
September	17,403	59	69
October	17,080	59	62
November	17,290	54.6	49
December	17,093	53.1	35
January, 1925	16,895	55.7	32
February	16,910	55.6	36

[2]Through the courtesy of E. H. Tenney, chief engineer of power plants, Union Electric Light & Power Co., and McClellan & Junkersfeld, designers of the station.

PHILO

The most recent addition to this group is the Philo Station of the Ohio Power Co. Operating results from this plant have been awaited with great interest because of its unusual features, which include throttle steam at approximately 550 lb. and 720 deg., with reheating to 720 deg., and a supply of canal water for condensing under a head that does away with pumping.

Results published in the May 12 issue of *Power* indicate that Philo has set a new record for station heat rate. The best figures were 14,315 B.t.u. for the week ending April 11 and 13,715 B.t.u. for the next with load factors of 89.8 and 86 per cent respectively. Other available results are 14,776 B.t.u. for the first twenty days of February and 14,806 for the two weeks ending March 21.

These results were obtained burning a low-grade bituminous slack (about 10,500 B.t.u.) on traveling grates. The Philo station uses both economizers and air heaters.

The effect of reheating on the station economy was indicated by a special turbine test with and without reheating. Reheating reduced the turbine's net heat consumption per kilowatt-hour from 12,080 B.t.u. to 11,600 B.t.u.

Synthetic Ammonia

In a lecture on "Synthetic Ammonia" before the New York Chapter of the National Association of Practical Refrigerating Engineers, R. J. Quinn, of the Mathieson Alkali Wks., stated that improvements in chemical engineering now make it possible to utilize for the production of ammonia large quantities of nitrogen and hydrogen occurring as byproducts in the manufacture of other chemicals. The purity of these gases is such that the resulting anhydrous and aqua ammonia excels in quality the ammonia recovered by the old processes from gashouse and coke-oven distillates. Synthetic ammonia must necessarily be subjected to very high pressures and temperatures and therefore reaches the market free from deleterious substances such as tar, pyridene, water, etc.

Discussion brought out the fact that a large portion of the ammonia sold today already is being produced by the synthetic process. Actual practice has demonstrated its refrigerating power to be at least equal if not superior to the ordinary kind. Accordingly, there is absolutely no justification for any prejudice against this new product of science. Halbert A. Hill remarked that many operating engineers still are laboring under the delusion that with their favorite brand of ammonia they can obtain materially better results and more ice than with some other brand. All brands on the market are at least 99.8 per cent pure, and variations in output certainly cannot be attributed to the quality of the ammonia used. Synthetic ammonia has been examined and the most careful investigation has failed to show any difference in quality. It was stated that prices did not differ from those coke-oven ammonia.

Iron and Steel Electrical Engineers Hold Fuel-Saving Conferences

Automatic Combustion Control as Applied to Boilers and Metallurgical Furnaces—Heat Insulation of Hot Surfaces and Furnace Walls—Generation of Steam from Coke Braize—A New Use for Blast-Furnace Gas

AT THE William Penn Hotel, Pittsburgh, Pa., on May 13 and 14, the Association of Iron and Steel Electrical Engineers held its second annual fuel conference. The outstanding thought coming out of this conference was the tremendous possibilities for fuel saving by automatic control of combustion, by the use of heat insulation, more efficient application of heat and a greater and more efficient use of waste heat from industrial-heating processes. One of the largest wastes in this country is that which occurs in the utilization of our fuels, and no other lends itself more readily to a reduction than does this waste.

Automatic Combustion Control for Boilers

On automatic combustion control there were five papers presented, one each, by C. H. Smoot, president of the Smoot Engineering Co.; Thomas Peebles, chief engineer, the Hagan Corporation; C. S. Carrick, president and general manager, the Carrick Engineering Co.; B. G. Bailey, president, the Bailey Meter Co.; and H. K. Huessener, president, the American Heat Economy Bureau.

From the papers and discussion it was evident that the problem of automatic combustion control of boilers was well in hand and that the results obtained were highly gratifying. These control systems have now reached a stage in their developments where they are being applied to some of the largest and most important plants. Attention was called to the evolution that coal-burning equipment has passed and is still passing through. Hand firing has almost entirely given way to the mechanical stoker, and those stokers requiring the most attention and labor are being superseded by those more responsive to control, with the final goal a coal-burning equipment that will respond to changing only the stoker or feeder speed and the rate of air supply, and thereby maintain proper fuel and air distribution, which is necessary for high combustion efficiency. The opinion was expressed that all the more popular methods of burning coal in use at present would continue to have their advocates for some time, but that the equipment that is most responsive to complete automatic control would prevail over the other methods.

Combustion Control on Metallurgical Furnaces

Although the use of automatic combustion control as applied to boilers is expanding rapidly, such control as applied to metallurgical furnaces has lagged. Practical experience with such control on these processes has shown the possibilities for high economy. In one case cited a fuel saving of 33 per cent has been attained with an increase in output of manufactured product. Other installations were referred to, where good results had been secured. In the steel plant the management has tonnage output in mind more than efficient burning of fuel, and this has been one of the biggest obstacles in the way of applying automatic combustion control to the different types of furnaces.

Stress was laid on the necessity of considering the human side in attempting to sell automatic combustion control or any other device. If the operator was not convinced that the equipment would do the work and that it would help him to do a better job, the apparatus was going to have a hard time to make a satisfactory showing.

Insulating Hot Surfaces

In a paper on "Insulation of Hot Surfaces and Furnace Walls," L. B. McMillian, consulting engineer, Johns-Manville, Inc., showed the possibilities of heat saving by properly insulating hot surfaces. Although it is generally realized that it is poor economy to operate with bare steam lines and other steam-heated surfaces, too little attention has been given to the other heated surfaces. By the use of a series of curves the effects of air currents over uninsulated heated surfaces were given. It was shown that with an air velocity of 800 ft. per min. the loss was about double that in still air. The effect of air flow over insulated surfaces will also increase the heat loss, but this loss will be small compared with uninsulated surfaces. The opinion was expressed that if furnace walls are properly insulated, the effect is beneficial rather than detrimental, since the wall is maintained at a more even temperature. In applying insulation it is not necessary for the heat saving to be large to pay a reasonable return on the investment. Even though some of the advantages of heat insulation cannot be evaluated, they should not be overlooked.

Burning Coke Braize

At the Thursday morning meeting two papers were presented on the generation of steam by burning coke braize under boilers; one by John Van Brunt, vice-president in charge of engineering, Combustion Engineering Co., and the other by G. C. Emmons, steam and efficiency engineer, Republic Iron & Steel Co. The method of burning coke braize that has proved most successful so far is the use of a chain-grate stoker with the proper type of furnace.

It was emphasized that the arch construction in the furnace has a very marked effect on the results that might be expected. Although successful operation has been obtained with a long front arch only, experience has shown that the front-and-rear arch construction in the furnace is to be preferred for a number of reasons. This arrangement gives a higher efficiency and the maintenance costs are lower. With the single-arch construction the length of the arch has to be made so long that all the combustion takes place under the arch and causes the highest temperature to be developed in this region. By using two arches, the front arch is shortened so that the zone of highest temperature is between the two arches.

Draft Pressure in Boiler Furnaces

Another factor is maintaining ignition of the fuel on the stoker. With a long front arch only, in one test made, it was found that with a negative pressure of 0.02 in. in the furnace, the maximum temperature was about 1,900 deg. F., with balanced draft the temperature increased to 2,150 deg., and with a positive pressure of 0.02 in., a temperature of 2,300 deg. was obtained. With balanced pressure and the two-arch construction about the same furnace temperature was obtained as with the single arch and a positive pressure of 0.02 in. The change from a positive pressure in the furnace and single-arch construction to a balanced draft with a front and rear arch reduced the combustible in the ash from 40 to about 10 per cent.

It was pointed out that to burn coke braize successfully it must be sized. If burning the larger sizes with the fines is tried, difficulty will be experienced with stratification of the fuel bed. The large sizes work to the sides and the fines to the center of the stoker, with the result that so much air will pass through the coarse material that combustion will be prevented.

Coke Braize Burned on Underfeed Stokers

Although the consensus of opinion was to the effect that it would be difficult to burn coke braize on an underfeed stoker, one successful installation was reported, but in this case it required careful handling of the stoker for successful operation.

One of the serious problems to be contended with when burning this fuel in pulverized form is its high abrasive action, which is also true to a certain extent when used on an underfeed stoker. Two installations were reported, where this material is being burned successfully in pulverized form in this country and a number in Europe. It is also burned in pulverized form in certain industries.

In a paper, "A New Use for Blast-Furnace Gas," G. R. McDermott, assistant chief engineer, Illinois Steel Co., the results obtained in the application of blast-furnace gas and air to blowing a gas producer instead of using steam were given. By the new method a net saving of 20 per cent in fuel for operation of the producer was reported.

Roanoke Power Project—The Roanoke-Stauton River Power Co. has applied to the Federal Power Commission for a preliminary permit covering a project on the Roanoke River. It is planned to build three dams in the Lynville ford area of the river, and two dams in the Anthonys ford area. The improvement will involve some sixty miles of the stream. No data has been submitted as yet as to the type of structures to be built or as to the power possibilities of the project.

New Station of New York Edison Company

Among the Outstanding Features of the East River Station Will Be 60,000-Kw. Units, Pulverized Coal, and Steam-Driven Auxiliaries

TO MEET an average growth of 10 per cent in its load the New York Edison Co. is building a new station to be located at Fourteenth Street and the East River. Two 60,000-kw. 25-cycle turbo-generators and a 40-000-kw. 25-60 cycle frequency changer will comprise the initial installation, and provision is being made for an ultimate installation of nine 60,000-kw. or larger units supplemented possibly at a later date by 160,000 kw. of mercury-turbine units. The guaranteed water rates for the main turbines are 9.54 lb. at 30,000 kw., 9.23 lb. at 40,000 kw., 9.5 at 50,000 kw. and 9.66 lb. at 60,000 kw.

The new station will serve primarily, the substations that supply the direct-current system for Manhattan, although the frequency changer will permit a tie-in and interchange of power at 60-cycles with Hell Gate and Sherman Creek Stations of the United Electric Light & Power Co. with the Brooklyn Edison Co. and other outside companies. The plant is laid out with a frontage of 206 ft. along the river, and there is room to extend back along Fourteenth Street for a distance of about 1,000 feet.

A later article will describe the plant in detail, after all the equipment has been selected. The design in general, while representing an advance in practice, is conservative to the extent that service in the Metropolitan District demands, above all else, reliability. For instance, the steam conditions selected, 375 lb. and 700 deg., are a compromise between the 275 lb. at Hell Gate and the 550 lb. as employed by some of the new stations in the Middle West.

Ten 15,500-sq.ft. boilers will go into the initial plant. These will be provided with fin-type water-cooled furnaces and interdeck superheaters, the latter located above the fourth row of tubes. Economizers will be employed, but there will be no air preheaters.

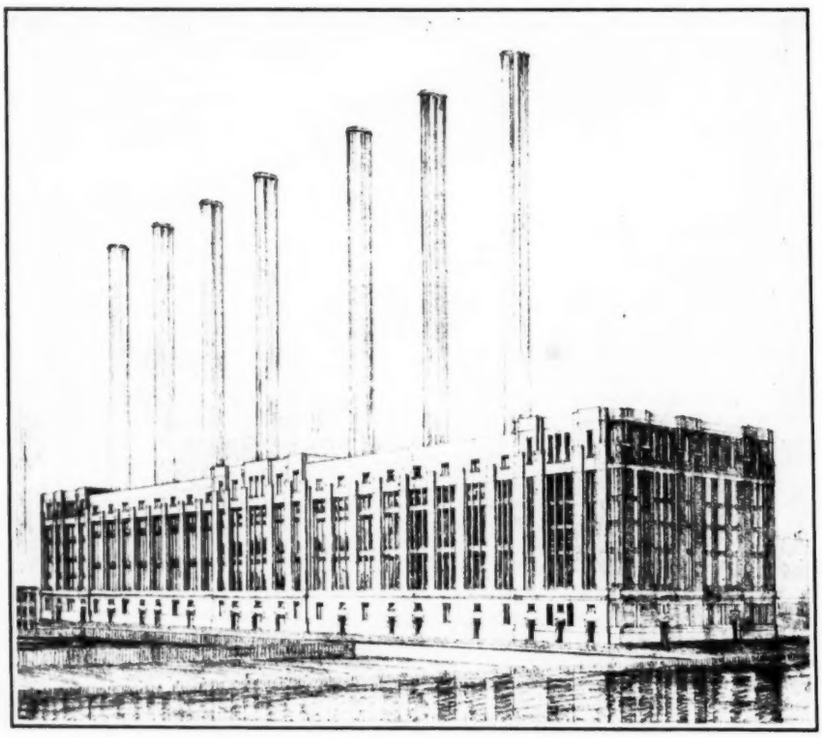
The decision to adopt powdered coal was made after an exhaustive study of a number of stations now thus equipped and after carefully weighing all factors, one of which was the relatively flat performance curve over a wide range in load.

Most of the auxiliaries will be steam driven. This includes the induced-draft fans, circulating pumps, hotwell pumps, boiler-feed pumps and ash-sluicing pumps. The turbines driving the circulating pumps will run condensing, each having its individual condenser. No attempt will be made to recover the heat from the generator coolers, East River water being used for this purpose.

In addition to the exhaust from the auxiliaries, the heat balance of the station will include steam bled at two points from each of the main units; that is, the boiler feed will pass successively from the hotwell through the first bled steam heater at 165 deg. F., a closed exhaust heater at 200 deg. F., the second bled steam heater, at 276 deg. F., thence through the economizer to the boiler. The first bleeder point will be 6 lb. abs. at full load from the eighteenth stage of the turbine and the second bleed point at 49 lb. abs. from the fourteenth stage.

Current will be generated at 11,400 volts, at which it will be transmitted to the various substations. Transformers in the station will supply alternating-current at 2,300 volts for the coal-handling motors and 440 volts alternating-current for a few minor auxiliaries. In addition 250-volt direct current will be available for certain station services.

The station is being designed by Thomas E. Murray, Inc.



Architect's drawing of the New York Edison plant

Four New Electrical Awards Created by J. H. McGraw

To encourage individual initiative and creative thinking among electrical men, James H. McGraw, of the McGraw-Hill Company, Inc., has established four annual awards, three to be competed for by the men of the manufacturing, jobbing and contractor-dealer branches of the electrical industry respectively and the fourth to be open, in addition, to the men of the central-station industry. These are in addition to the award already established for the central-station industry exclusively.

Each award will take the form of a bronze medal and a purse of one hundred dollars in gold. The Society for Electrical Development has been requested to act as sponsor for these awards, and it has appointed a Committee of Awards which will prepare an appropriate medal and conduct the contests.

The first competition for these four McGraw Awards will close on Sept. 1. Candidates must submit their statements not later than this date, addressed to the James H. McGraw Awards, Society for Electrical Development, 522 Fifth Ave., New York City. Information and advice may also be obtained from this society.

Summer Courses at Carnegie Institute of Technology

The Carnegie Institute of Technology, Pittsburgh, has announced that it will give summer courses from six to eight weeks beginning June 15 for undergraduates and those in engineering work who feel the need of more technical training in their respective fields. The College of Engineering will give courses in chemistry, physics, mechanics, engineering drawing, descriptive geometry and surveying. A special short course in coal mining will be given in co-operation with the U. S. Bureau of mines.

Young Engineer Honored for Courage

At the April meeting of the Oklahoma Gas & Electric Co. Club in Heavener, Okla., Ancel M. Salyars was honored by his fellow workers and the company for the courage displayed by him during a crisis. He is superintendent of the gas and electric company and also is in charge of the pumping station that supplies the water to the town. On Christmas night a water valve froze and burst, flooding the motors in the pump pit. He worked for hours trying to stop the leak without success. There was a valve under the river, which could it be opened, would drain the pit. But the river was frozen over. The young superintendent took a pick, cut a hole in the ice and dived down to the drain valve. He tugged at it until he finally got it open. He then set to work, in his frozen clothes, to dry out the motors and started the pumps to work again, which took the rest of the night.

Ambrose Swasey Honored by Foundation Board

The Engineering Foundation Board honored Ambrose Swasey at a dinner held at the Union League Club on May 14, which was attended by prominent officials of the engineering societies.

Appropriate resolutions were tendered Charles F. Rand, who has resigned as chairman of the Foundation, and the report of the nominating committee on the acceptance of the chairmanship by Lewis B. Stillwell was read. Alfred D. Flinn presented the report of the work of the Foundation on the arch dam test, the fatigue of metals investigation, and the work of research now under way. A letter from a society of architects and artists in regard to the possibilities of art in connection with engineering was then read.

Addresses were made by Edward Dean Adams, vice-president, presiding; Frank B. Jewett, of the American Telephone & Telegraph Co., who spoke on "Permolloy Cables," a recent invention which has increased the efficiency of cables so that 2,000 words can now be sent one way where before only 480 a minute could be sent, and permits of the sending of 100,000,000 words a year. J. V. W. Reynders, for the Founders Societies, presented Mr. Swasey with an embossed testimonial. Photos of themselves, which had been sent over the wires from San Francisco, were presented to Mr. Adams and Mr. Swasey. Mr. Swasey then responded to the congratulations and honors.

Power Alcohol May Be Produced in Australia

An agreement between M. Theodore, Premier of Queensland, and one of the large sugar companies of that State, has been entered into for the production of power alcohol, and it is intended to proceed with the industry provided the assistance of the government is forthcoming, as recommended by Mr. Lightfoot, of the Commonwealth Bureau of Science and Industry.

There is great likelihood that the International Sugar & Alcohol Co. (controlled by the Distillers' Co., Ltd., of Edinburgh) will establish a company in Queensland for power alcohol production. R. V. Board, who is representing the International company, is at present in Queensland, and at the invitation of the state government is investigating the possibilities of such an industry. Mr. Board states that so far his investigations "have been very encouraging indeed," and he is convinced that there are great possibilities for the production of power alcohol in Australia. He further says he can see "no reason why the bulk of the liquid fuel consumed in Australia should not be produced within its own boundaries."

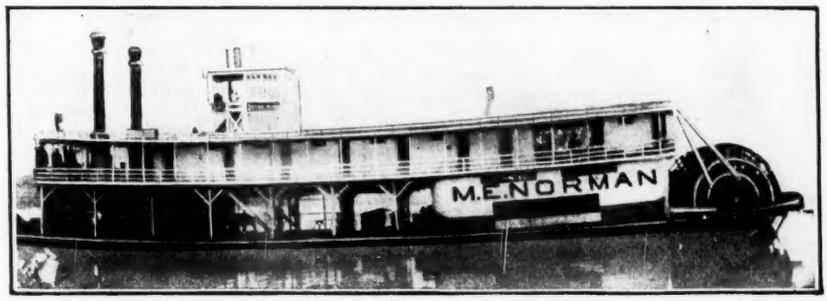
The present proposal is not only to utilize the molasses which is going to waste, but to produce the alcohol in excess of the quantity that could be provided from the molasses, from crops grown close to the scene of production.

Giving evidence before the Federal Public Accounts Committee, which is inquiring into the expenditure on the question of search for oil in Australia and also other sources of liquid fuel, Mr. Board said that if the manufacture was to be conducted on a large scale, continuous and large crops must be available. The company would be under Australian management with Australian capital, backed up with a small percentage of British money. He stated that if power alcohol were to be produced cheaply it must be produced near where the crops were grown. The production of 60,000,000 gal. would provide for the cultivation of 120,000 acres with crops. There were many crops suitable, but he advocated cassava, sweet potatoes and arrowroot in that order. It was proposed to establish alcohol distilleries near and under control of the sugar mills. This would provide for the use of the machinery at present idle for half the year.

Engineering Convention Ends in River Disaster

Twelve engineers, five women of their party, a boy and four members of the crew of the stern-wheel steamer "M. E. Norman," were lost on May 8 when that boat, carrying a part of an inspection party from the First Annual Convention of Engineers of the Mid-South, capsized in midstream of the Mississippi near Coahoma Bend about 12 miles south of Memphis. Those reported as lost were:

Paul H. Norcross, consulting engineer, Atlanta, Ga.; William M. Gardner, U. S. Assistant Engineer, Memphis, Tenn.; Charles H. Miller, pres., Miller-Butterworth Co., Little Rock, Ark.; Ralph Bosard, Morgan Engineering Co., Memphis (body found); Mrs. R. Bosard and son, Edgar (body found); Charles E. Shearer, consulting engineer, Memphis; S. Waters Fox, Joyce-Watkins Co., Paducah, Ky.; Edmund H. Bowser, Supt., Illinois Central Timber Treating Dept., Memphis, Tenn.; George L. Anderson, chief draftsman, Ayres & Miller, Memphis, Tenn.; Walter G. Kirkpatrick, prof. of municipal engineering, University of Mississippi (body found); Mrs. W. G. Kirkpatrick; William Hannum, supt. of const., Phœnix Utility Co., Memphis; Robert H. McNeilly, prof. of civil engineering, Vanderbilt University; Mrs. Lydia Hidinger, mother of L. L. Hidinger, Pres., Morgan Engineering Co., Memphis; Mrs. J. H. Dorroh, wife of Prof. J. H. Dorroh, University of Mississippi; Mrs. L. W. Caldwell, Memphis, Tenn.; William O. Walker, resident engineer, H. W. Nelson Co., Fulton, Ky.; 4 members of the crew.



Mississippi River boat which sank with party of engineers

The "M. E. Norman" was a typical Mississippi River boat which had been purchased by the Mississippi River Commission early this year. She was 111 ft. long and 26 ft. beam, driven by oil engines. She had been tested thoroughly early this year on an 800-mile trip carrying more than double the load carried on May 8. In a recent test the rudder was held hard down to drive the boat in a circle at full speed. Practical navigation experts of the Commission had pronounced her satisfactory.

W. W. DeBerard, Western editor of *Engineering News-Record* was one of those saved. He states that owing to the level-headedness of the engineers and to the heroic efforts of Tom Lee, the negro employed by the Tennessee Construction Co., who in his motor boat systematically picked up the survivors, 90 per cent of those who escaped owe their lives.

Efficiency in Utilization of Fuel Increases

A report prepared by the Geological Survey on the production of electricity by public-utility power plants for 1924, shows that the average amount of coal used to generate a kilowatt-hour of electricity has decreased 1 lb. in the five-year period since 1919. In 1913 3.2 lb. of coal was consumed in generating a kilowatt-hour of electricity. In 1924 2.2 lb. was required. In 1919 a ton of coal, when utilized in a public-utility power plant to generate electricity, produced 625 kw.-hr. In 1924 a ton of coal produced 909 kw.-hr. These figures represent an increase of 45 per cent in efficiency in the utilization of fuel. These results are based on the operation of all plants. Some plants are producing nearly 2,000 kw.-hr. to the ton of coal.

The report shows that public-utility power plants generated 6 per cent more electricity in 1924 than in 1923 and that nearly 34 per cent of the total output was produced by the use of water power. The amount of coal consumed in generating electricity was nearly 4 per cent less than in 1923, whereas the amount of fuel oil and natural gas consumed increased 13 and 54 per cent, respectively. California alone consumed 40 per cent of the fuel oil and 46 per cent of the natural gas utilized by public-utility power plants in the United States in generating electricity.

California, after ranking first since 1921 in the production of electricity by the use of water power, dropped into second place in 1924, New York taking first place by a considerable margin. California, however, jumped from eleventh place in the production of electricity by the use of fuels in 1923 to fifth place in 1924, outranking Massachusetts and Michigan, leading industrial states. Illinois displaced Pennsylvania as the leading state in the amount of coal used by electric public-utility power plants, but not in the amount of power generated from coal.

Mid-West Power Show To Be Held in Auditorium

The Mid-West Power Show and Mechanical Exhibit which is to be held in Milwaukee May 18-23 will have many engineer visitors, as the show is being held during the week of the annual meetings of the A.S.M.E., A.S.R.E. and the Wisconsin Section of the N.A.S.E.

This is the first show of its kind to be held west of New York and its organizing committee, which is headed by John A. Wickert, has worked hard to make it a success. Over 300 exhibitors have contracted for space in the Auditorium and in Kilbourn, Juneau and Walker Halls. All phases of power-plant engineering are well represented, and a visit will be well worth the time spent. Speakers of national reputation have been engaged to address the visitors and other entertainment provided.

There will be no charge for admission to the Power Show, but admission will be by ticket only. Tickets can be obtained from any exhibitor or the executive committee. Delegates and guests to the A.S.M.E., A.S.R.E. and N.A.S.E. meetings will be admitted by showing their badges issued by the respective organizations or will be given tickets at their respective headquarters. Anyone connected with or interested in power plants can obtain admission tickets from the Power Show Management, Ralph H. Cahill, secretary, City Hall, Milwaukee.

Two Lectures for A.S.M.E. Annual Meetings Program

Two lectures, to be known as the Henry R. Towne Lecture and the Robert Thurston Lecture, were added to the programs of annual meetings of the A.S.M.E.

The Henry R. Towne lecture is to deal with topics in the zone between engineering and economics, and the Robert Henry Thurston lecture, with subjects in the zone between engineering and science. Lecturers will be presented with parchments bearing the seal of the society and the signatures of some of its officers, testifying to the fact that they have delivered such lectures before the A.S.M.E.

President Will Await Muscle Shoals Commission Report

President Coolidge is unwilling to make any temporary disposition of power produced at Muscle Shoals until convinced that by so doing he would not hamper the establishment of a permanent policy with reference to the property.

The President's present intention is to await the report of the commission which has been appointed to survey the problem before making any move. He considers that the object of the government must be to obtain from the property the greatest possible public utility and at the same time the greatest possible return to the Treasury.

Since the House of Representatives has adopted a formal resolution that no temporary disposition be made of the power, the Administration is absolved of any criticism that might arise from the loss of $100,000 a month in revenue.

Program of the A. S. M. E. Spring Meeting
Milwaukee, May 18-21

Papers of Interest in Power Plant Field

Monday morning — Council meeting.

Monday afternoon — Business meeting of society; meeting of A. S. M. E. Council; Boiler Code public hearing; excursion to Sewage Disposal Plant, Palmolive Co., Phœnix Hosiery Co.

Monday evening—Reception.

Tuesday morning—"A Microscopic Study of Pulverized Coal," by L. V. Andrews; "Radiation in the Pulverized Fuel Furnace," by Walter J. Wohlenberg and Donald G. Morrow; "Boiler Furnaces for Pulverized Coal," by A. G. Christie; "The Parallel Operation of Hydro and Steam Plants," by F. A. Allner; "Mechanical Features Affecting the Reliable and Economical Operation of Hydro-Electric Plants," by E. A. Dow; "Mechanical Problems of Hydraulic Turbine Design," by William M. White.

Tuesday afternoon—Excursions to Allis-Chalmers Manufacturing Co., Kline's Inc. (powdered fuel plant), Robt. A. Johnston Co., Kearney & Trecker Co.

Tuesday evening — Milwaukee Session—"The Activated Sludge Sewage Disposal Plant at Milwaukee," by John A. Wilson; "Critical Study of Heat and Power Requirements of Sewage Disposal Plants," by Robert Cramer; "Duty Tests of Vertical Triple Expansion Pumping Engines, Milwaukee, Wis.," by Charles A. Cahill; "The Economical Advantage of Cities Having Diversified Industries," author to be announced.

Wednesday morning — "Torsional Vibration and Critical Speeds of Shafts," by Dr. Arnold Lack; "Tests of a Unaflow Engine," by G. H. Barrus; "The X-Ray Examination of Steel Castings," by I. E. Moultrop and E. W. Norris; National Defense Session.

Wednesday afternoon—Excursions to Vilter Manufacturing Co., Riverside Pumping Station, Falk Corporation.

Wednesday evening — Dinner and public meeting. Speeches will be made by Dwight F. Davis, Assistant Secretary of War; ex-Governor Emmanuel of Wisconsin; the Rev. W. T. Dorwood; William F. Durand, president of the A. S. M. E. Fred H. Dorner will preside.

Thursday morning—"A Review of Steam Turbine Development," by Hans Dahlstrand; "Rational Design of Covering for Pipes Carrying Steam Up to 800 Deg. F.," by W. A. Carter and E. T. Cope; "Analysis of Power Plant Performance Based on the Second Law of Thermodynamics," by W. L. DeBaufre; "Lake Waters for Condensers," by A. G. Christie; "Comparison of Actual Performance and Theoretical Possibilities of the Lakeside Station," by M. K. Drewry.

Thursday afternoon—Excursions to Lakeside Power Station and Nordberg Manufacturing Co.; Joint Session with the American Society of Refrigerating Engineers — A Public Hearing on Joint Test Code for Refrigerating Apparatus and Plant.

Amsterdam Using Unit Pulverizers

Amsterdam Electricity Authorities have recently ordered from Alfred Herbert, Ltd., Coventry, four large Atritor unit pulverizers, each capable of pulverizing 6,000 lb. of bituminous coal per hour. These machines will fire a large Clayton water-tube boiler having a normal evaporation of 154,000 lb. of water per hour to a pressure of 45 atmospheres (662 lb. per sq.in.) and superheated to 375 deg. C. (707 deg. F.)

The boiler will be fitted with a special water-cooled combustion chamber designed by Dr. Lulofs and as efficiencies of 90 per cent have been attained with smaller boilers fired in this manner, it is anticipated that these results will be exceeded with the new installation.

The pulverizers will be driven in pairs by efficient non-condensing steam turbines and the exhaust steam can be utilized for feed-water heating.

A 4,000-lb. of coal per hour pulverizer has been in use at this power station for some time and another of the same capacity has been recently ordered. This will run in conjunction with the existing one, both being driven by steam turbine and firing the same boiler.

America's Position in Modern World Trade Outlined

In an address by L. W. Wallace, executive secretary of the American Engineering Council on May 5, before the Cleveland Chamber of Commerce, on "How May American Industry Maintain Its Position in World Trade?" some pertinent thoughts were put forth. Mr. Wallace said in part:

"Authorities agree that the world is on the eve of the most aggressive struggle for world markets ever experienced. A new era is being entered upon which will require the reformulation of major economic policies. No one can predict what those policies shall be. It is certain they will have to be evolved by expert and scientific study of conditions.

"The character of the policies necessary to safeguard American industry may be visioned by a few comparisons. We know that we have as good if not better industrial management than Europe. Undoubtedly, good management is more universal here than in Europe. We also know, however, that an enormous waste is occurring in American industry.

"European industry has an unlimited supply of cheap labor. We have a limited supply, and labor in America is paid more in real money than anywhere else in the world. Furthermore, American industry and commerce will be confronted with an annual reduction in the addition to the unskilled labor supply of about 800,000 as compared with years previous to the war, by reason of the restricted immigration policy.

"The only way to offset this loss and to maintain the standard of wages paid in the United States, is to extend the use of material handling and processing machinery and eliminate the waste of human labor due to accidents, illness and the intermittent operation of industry.

"The situation with reference to high wages and limited supply of labor can also be met by more uniform production schedules. A large number of our basic industries are idle from 30 to 40 per cent of the working days per year. Recent studies by the Department of Commerce, the American Engineering Council and other national bodies clearly show that such intermittent operation is wholly unjustified and unnecessary.

"Europe probably leads America in industrial research. An American engineer who visited over fifty research laboratories in Europe and England last summer told me he was astounded by what was going on. In Germany particularly they have been feverishly preparing for the economic struggle upon the threshhold of which we are standing at this moment. I am informed that the industrial world at least, will be startled as soon as some of the things ready to be put into operation come to light.

"While a great deal of money is being spent in America for research, we do not appear to so organize, co-ordinate and direct it as to get the immediate results that the Europeans do.

Mass Production America's Specialty

"One of the most profound thinkers of America has suggested that since America is the leader of the world in mass production, it should capitalize that fact by specializing on those things it can successfully enter the world markets with, because produced under mass production system. That is, let Germany, England or Poland have the markets they are able to command because of cheap labor, and American industry take the markets it can because of mass production and notwithstanding the high standard of wages paid and the scarcity of labor.

"In the area of distribution, billions of dollars are wasted annually. Recently, Secretary Hoover enumerated fifteen causes of waste in distribution. Briefly, they are: Speculation, relaxation of effort and extravagance of booms; excessive seasonal character of production and distribution; lack of information of national stocks, of production and consumption; lack of standards of quality and grades; unnecessary nullification of terms, sizes and varieties; lack of uniformity of business practices in terms and documents; deterioration of commodities; inadequate transportation and terminals, inefficient loading and shipping and unnecessary haulage; disorderly marketing, particularly of perishables, with its attendant gluts and famines; too many links in the distribution chain and too many chains in the system; bad credits; destructive competition; enormous expenditure of effort and money in advertising sales promotion effort without adequate basic information; unfair practices of a small minority; multitude of wastes in the use of materials, in unnecessary fire destruction, in traffic accidents and many other directions.

"Secretary Hoover asserts the remedy lies in investigation, negotiation and decision, and solemn statistics are the greatest preventive of speculation and profiteering ever invented."

A. S. R. E. Meeting Program

THE American Society of Refrigerating Engineers will hold its Twelfth Western meeting at the Hotel Wisconsin, 172 Third St., Milwaukee, Wis., May 20-22.

Papers of interest to readers of *Power* are:

"Flywheel Requirements for Unbalanced Reciprocating Compressors," by C. W. Cutler, General Electric Co., Schenectady, N. Y.

"Motor Drives for Ammonia Compressors," by Theodore Schou, Ideal Electric & Manufacturing Co., Mansfield, Ohio.

"Shell and Tube Type Ammonia Condenser Design and Methods of Construction," by L. H. Burkhart, Struthers-Wells Co., Warren, Pa.

"Complete Automatic 50-Ton Refrigerating Plant for Processing Cotton," by F. L. Fairbanks, Quincy Market Cold Storage & Warehouse Co., Boston, Mass.

An excursion to the Vilter Manufacturing Co., a dinner dance and other entertainment have been provided.

New Brunswick Development Affects Maine

The International Joint Commission on development of power along the Canadian-United States border made public on May 9, a statement in which the State of Maine asserts that it should receive its share of electric power from the station on the St. John River near Grand Falls, N. B., which the New Brunswick Hydro-Electric Commission plans to develop and which will raise the water level in the international section.

The Canadian National and Canadian Pacific Railways and the Canadian and United States governments have also filed statements with the commission, it was learned, and a statement from the International Paper Co. of New York is expected soon.

The Department of State should interest itself formally in the questions involved in the proposed development of a power project in the St. John River by the Province of New Brunswick. Opinions to the foregoing fact are reaching Washington from persons thoroughly conversant with the project. At present the State of Maine is the only interest that has concerned itself with American equities in this development. The feeling is that the individual states are scarcely competent to represent the country, as a whole, which is interested in the development of international streams.

It is believed that conditions should be laid down in advance which will insure the return to the United States of its share of the power without the payment of export duties.

Colonel Kelly to Be Associated with the N. E. L. A.

Col. William Kelly, chief engineer of the Federal Power Commission since its creation, is winding up his work preparatory to the assumption of his new duties as director of engineering for the National Electric Light Association. He will retain his title of chief engineer until after a meeting of the Commission to be held later this month, so he may participate in that meeting, at which a number of important matters must be decided. He will continue to serve as a member of the Joint Engineering Board for the St. Lawrence River.

Colonel Kelly will take a short vacation before entering upon his new duties.

Saguenay River Project To Be Completed This Summer

The Quebec Development Company's Isle Maligne, the 540,000-hp. hydroelectric power project on the Saguenay River at the part called the Grand Discharge of the Lake St. John, has advanced so that its completion by the middle of the summer of 1925 is assured.

Four of the twelve units of 45,000 hp. each are now in operation under a low head, which will eventually be increased to about 110 ft. The power house is completed so far as the concrete substructure and bulkheads are concerned. Stationary portions of the waterwheel machinery are all erected and enveloped in concrete, and the installation of turbines and generators practically completed for four units and under way on six more. The installation of the butterfly-valve headgates is being proceeded with. Each of these gates weighs 54 tons. Three spillways are finished and the fourth well advanced.

Synthetic Lubricating Oil Germany's Aim Now

Reports from Germany indicate that conspicuous success is attending the effort to produce lubricating oils synthetically. The process is similar to that used in the production of menthenol—synthesizing carbon monoxide and hydrogen under high pressure and temperature in the presence of the catalyst. The product is known as synthol and is declared to be similar to caucasian petroleum. While this product has not been produced commercially, the chemical and engineering difficulties apparently are yielding to intensive study.

The commercialization of menthenol came suddenly, and technical men in the government service see in this spectacular incident the creation of a new appreciation of research on the part of the people and of Congress. An expansion of the government's research work is expected to result, but the general opinion is that the more important result will be the undertaking of scientific programs by private industry generally.

There is reason to believe that the production of other alcohols through the application of the same principles is under way in Germany. Unquestionably, these developments brings a process of gas synthesis within hailing distance of the great market offered motor fuels.

Sydney Considering a New Power Plant

Sydney, Australia, is considering the discontinuing, at its expiration date in 1930 the existing city-lighting contract with the New South Wales Railway Commission and of taking immediate steps for the erection of a city-council power house to be ready for operation in 1930. The proposed new plant would be a basis for a source of electric supply which would be state-wide. The proposal calls for a bond issue of £3,000,000, according to information supplied to *Commerce Reports* by Consul E. M. Latton, Sydney, Australia.

Technical Program of the N.E.L.A. June Meeting

Papers of interest to *Power* readers which are on the tentative program to be given at the national convention of the N.E.L.A., San Francisco, Calif., June 16-19, besides reports of Electrical Apparatus Committee, Hydraulic Power Committee, Prime Movers Committee will be: "Some factors Affecting the Relation of Steam and Water Power in Combined Systems," by Herbert A. Barre, Southern California Edison Co.; "Special Features in Western Turbine and Waterwheel Design," by Ely C. Hutchinson, Pelton Waterwheel Co.; "The Spirit Which Permeates the Service of our Utilities," H. Birchard Taylor, Wm. Cramp & Sons Ship & Engine Building Co.; "The Status of the Engineer," E. F. Pack, vice-president of the N.E.L.A.; "The Engineer as a Factor in Human Affairs," by William F. Durand, president of the A.S.M.E. Addresses of general interest will be given by F W. Richardson of California, William M. Jardine, secretary Department of Agriculture, L. J. Tabor, National Grange and other speakers.

$150,000,000 Light and Power Merger Announced

Power service to contiguous territory said to represent the largest per capita consumption of electrical energy in the United States would be placed under unified financial control by a merger of four Western New York power companies, plans for which were formally announced on May 11. The effective date of the unification, proposed as July 1, will depend upon the sanction of the New York Public Service Commission, from which permission will be sought immediately.

Control of the Buffalo General Electric Co., the Niagara Falls Power Co., the Niagara, Lockport & Ontario Power Co., and the Tonawanda Power Co. would be centralized by an exchange of stock in the Buffalo, Niagara & Eastern Power Corp., a holding company to be organized for the purpose. The constituent companies would preserve their corporate entities as operating subsidiaries of the Buffalo, Niagara & Eastern.

Physical interconnection of the facilities of the companies and their unified operation would enable each company to draw upon the others for needed power whenever any of the companies had surplus available and would eliminate duplication of investments, particularly in power plants, and would work for the most efficient use of the existing supply of power, it was announced. A rumor of this merger was published in the April 14 issue.

American Engineering Council Board Meets

The Administrative Board of the American Engineering Council met at the Philadelphia Engineers Club on Friday and Saturday, May 8 and 9, the executive committee having met on Thursday evening.

Prof. Joseph W. Roe presented a report for the Committee on Aëronautics, recommending a study of the possibilities of commercial aviation, and it was decided to appoint a committee to inquire into the possibilities and practical scope of such a study and sources for its support.

The committee on a Department of Public Works presented a draft of a bill to be presented at the next session of Congress.

The secretary's report reviewed the activities of the past quarter and the treasurer's report showed the Council to be in a satisfactory condition financially.

Resolutions expressing the pleasure of the members of the Council of the news of the recovery of President Hartness, and of regret for the accident to the members of the Mid-South Engineers Convention were authorized.

Personal Mention

Harry L. Barnits, consulting and construction engineer specializing in gases, announces the removal of his office to 2 Rector St., New York City.

Irving F. Goodfriend has accepted a position as technical assistant in the oil engineering department of the De La Vergne Machine Co., New York City.

L. W. Heller has just resigned the position of general superintendent of power stations of the Duquesne Light Co., of Pittsburgh, to accept the position of general manager with the Bailey Meter Co., Cleveland, Ohio.

H. A. Sherwood, formerly employed by the Virginian Railroad, has been appointed chief engineer of the Brotherhood of Locomotive Engineers Bank Bldg., Cleveland, Ohio. The plant will furnish light for the Engineers Bldg. as well as for the bank building.

Joseph Lappin has left his position as manager of the Detroit office and district engineer of the Pittsburgh office of the Combustion Engineering Corp. and has started in business for himself in New York City under the name of Joseph Lappin, Inc. He will specialize in boiler-plant equipment.

Business Notes

The Engineering Supervision Co., Inc., consulting operating engineers, announces the removal of its offices to 250 Park Ave. at 46th St., New York City.

The Shelvin Engineering Co., Inc., power plant and heating contractors, announces the removal of its home office to Hedwig St., near Hemlock St., Maspeth, N. Y.

The Union Iron Works, manufacturers of steel boilers, Erie, Pa., has recently moved its New York office from 50 Church St. to 122 Greenwich St. to provide better facilities. The office is in charge of Jos. Lappin.

The Cutler-Hammer Manufacturing Co., electric controlling devices, Milwaukee, Wis., has consolidated its two New York City offices, one of which was at 50 Church St. and the other in the Times Building. The new offices are to be at 8 West 40th St.

The Lincoln Electric Co., Cleveland, Ohio, announces that R. E. Kinkead, former chief engineer of the welder division, has been transferred to the sales department as regional director of sales, with headquarters in the company's offices, Ellicott Square Bldg., Buffalo, N. Y.

The Pennsylvania Pump & Compressor Co., Easton, Pa., states that: T. J. Barry, Park Bldg., Pittsburgh, Pa., has been appointed district representative for the Pittsburgh district; H. P. Rodgers, 508 Leader-News Bldg., Cleveland, Ohio, has been appointed district representative for the Cleveland territory; Whitman & Brandt, 705 Bona Allen Bldg., Atlanta, for Atlanta territory; James McGraw, Inc., 10th & Carey Sts., Richmond, Va., for Virginia territory.

The Industrial Works, Bay City, Mich., announces the opening of two new district offices: New Orleans, La., 425 Whitney Central Bldg., in charge of John A. Abele, district representative; Atlanta, Ga., 843-A Hurt Bldg., in charge of John J. Murphy, district representative; the appointment of Douglas J. Calder, Conway J. Neacy and Monroe J. Frankel as additional sales engineers at the Chicago, Ill., office, 1051 McCormick Bldg. and Chester F. Delbridge will be located at the St. Louis office, Railway Exchange Bldg., St. Louis, Mo.

The Foote Bros. Gear & Machine Co., 215 N. Curtis St., Chicago, Ill., announces that J. W. Hildebrand, formerly with the Jones Foundry & Equipment Co., has recently joined the sales force of the company; Gibbens & Gorden, 532 Canal St., New Orleans, La., is distributor in the New Orleans territory; Fulton Engineering Co., 612 American Bank Bldg., Los Angeles, for Southern California and Arizona; Paul C. Burton, formerly with the National Automatic Tool Co., and the Mechanical Engineering Co. has joined the engineering force; John A. Park, Gran Hotel, Avenida, Uraguay, No. 12 Mexico City is its representative in Mexico.

Coming Conventions

American Association of Engineers. C. E. Drayer, 63 East Adams St., Chicago, Ill. Convention at Orlando, Fla., June 2-5.

American Boiler Mfg. Association, H. N. Covell, 7 East 19th Ave., Brooklyn, N. Y. Meeting at Glen Spring Hotel, Watkins, N. Y., June 1-3.

American Society for Testing Materials. C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, Chalfonte-Haddon Hall, June 22-26.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Regional convention, at Swampscott, Mass., May 7-9. Annual convention at Saratoga Springs, June 22-26.

American Society of Heating & Ventilating Engineers. F. C. Houghten, 29 West 39th St., New York City. Semi-annual meeting at Traymore Hotel, Atlantic City, June 15-17.

American Society of Mechanical Engineers—Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Milwaukee, Wis., May 18-21.

American Society of Refrigerating Engineers. William H. Ross, 35 Warren St., New York City. Convention at Milwaukee, May 18-21.

Electric Power Club. S. N. Clarkson, B. F. Keith Bldg., Cleveland, Ohio. Convention at Hot Springs, Va., May 26-29.

International Railway Fuel Association. J. B. Hutchinson, Pa. R.R. System, Chicago, Ill. Seventeenth Annual Convention at Hotel Sherman, Chicago, Ill., May 26-29.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Convention at Chicago, May 19-22.

Mid-West Power Show at Milwaukee, Wis., May 18-21. Ralph H. Cahill, care of Mid-West Power Show, City Hall, Milwaukee, Wis.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. National convention and exhibition at St. Paul, Minn., Aug. 31-Sept. 4. Annual conventions and exhibitions of state associations are scheduled as follows: **Wisconsin Association** at Milwaukee, May 18-22. F. W. Horn, 256 29th St., Milwaukee, Wis. **Illinois Association at Decatur.** Olaf Jacobsen, 837 Lake Side Place, Chicago. June 3-5. **New Jersey Association** at Atlantic City, June 4-8. H. W. Vail, 1244 Park Ave., Plainfield, N. J. **New York Association** at McAlpin Hotel, New York City, June 11-13, W. T. Meinzer, 3rd St., near Warburton, Bayside, L. I. **Iowa State Association** at Ottumwa, June 16-18. F. L. Stocker, 127 S. Elm St., Ottumwa, Iowa. **New England States Association** at Worcester, Mass., July 9-11, formerly announced July 10-12. F. L. Tyler, 32 Briggs St., Taunton, Mass. **Ohio Association** at Middleton, Ohio, June 18-20. T. S. Garrett, 2622 East Second St., Dayton, Ohio. **Connecticut Association** at New Haven, June 25-27. George F. Klopfer, 30 East Pearl St., New Haven. **Michigan Association at Muskegon,** July 15-17. Charles Unterreiner, 5522 Underwood Ave., Detroit, Mich. **Minnesota Association** at St. Paul, Aug. 24-28. C. A. Nelson, 800 22nd Ave., Minneapolis, Minn.

National District Heating Association. D. L. Gaskell, Greenville, Ohio. Sixteenth annual convention at West Baden Springs Hotel, West Baden, Ind., May 19-22.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St., New York City. Annual convention at San Francisco, June 15-20.

Smoke Prevention Association—Frank A. Chambers, 1411 City Hall Sq. Bldg., Chicago, Ill. Nineteenth annual convention at Hotel Pantlind, Grand Rapids, Mich., June 17-20.

Southern Exposition—C. F. Roth, Grand Central Palace, New York City. Exposition May 11-23, at Grand Central Palace, New York.

Trade Catalogs

Evaporator — The Griscom-Russell Co., 90 West St., New York City. Leaflet describing the Reilly evaporator set which is designed to supply small quantities of boiler-feed makeup or makeup water for inclosed-jacket water-cooling systems.

Couplings, Flexible—The Falk Corp., Milwaukee, Wis. Bulletin No. 35 describes the types of flexible couplings now made by the company, styles AS and AL formerly made are now being discontinued, and sizes No. 125 and 220 are being added. Tables of ratings, and other useful information are included in the catalog.

Generating Sets—Engberg's Electric & Mechanical Works, St. Joseph, Mich. Catalog No. 105, "Direct-Current Generating Sets," gives details of construction, by means of blueprint drawings, tables of weights and dimensions, and boxing list of spare parts, and complete textual and photographic descriptions of each part as well as of the entire set.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; *mine run* except Pittsburgh gas slack (*Coal Age*):

Bituminous, Net Tons	Market Quoting	May 11, 1925
Pool 1	New York	$2.35@$2.75
Smokeless	Boston	1.54
Clearfield	Boston	1.75@ 2.20
Somerset	Boston	1.90@ 2.25
Kanawha	Columbus	1.35@ 1.50
Hocking	Columbus	1.35@ 1.50
Pittsburgh	Pittsburgh	1.90@ 2.00
Pittsburgh gas slack	Pittsburgh	1.40@ 1.60
Franklin, Ill.	Chicago	2.25@ 2.50
Central, Ill.	Chicago	2.00@ 2.25
Ind. 4th Vein	Chicago	2.25@ 2.50
West Ky.	Louisville	1.25@ 1.50
S. E. Ky.	Louisville	1.15@ 1.50
Big Seam	Birmingham	1.50@ 2.00
Anthracite, Gross Tons		
Buckwheat No. 1.	New York	$2.00@$2.60
Buckwheat No. 1.	Philadelphia	2.25@ 2.75
Birdseye	New York	1.40@ 1.60

FUEL OIL

New York—May 14, light oil, tank-car lots; 28@34 deg. Baumé, 5¼c. per gal.; 36@40 deg., 5½c. per gal., f.o.b. Bayonne, N. J.

St. Louis — May 6, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.75 per bbl.; 26@28 deg., $1.80 per bbl.; 28@30 deg., $1.85 per bbl.; 30@32 deg., $1.90 per bbl.; 32@36 deg., gas oil, 4¾c. per gal.; 38@40 deg., 5½c. per gal.

Pittsburgh—May 7, f.o.b. local refinery; 30@34 deg. fuel oil, 5c. per gal.; 36@40 deg., fuel oil, 5¾c. per gal.

Dallas—May 2, f.o.b. local refinery, 26@30 deg., $1.40 per bbl.

Philadelphia — May 7, 28@30 deg., $2.21@$2.273 per bbl.; 18@22 deg., $1.90@$1.963; 13@16 deg., $1.785@ $1.85 per bbl.

Boston—May 11, tank-car lots, f.o.b. heavy oil, 12@32 deg., Baumé, 4½c. per gal.; light oil, 28@32 deg. Baumé, 5¾c. per gal.

Cincinnati — May 12, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5¼c. per gal.; 26@30 deg., 5½c. per gal.; 30@32 deg., 5¾c. per gal.

New Plant Construction

Calif., Azusa—City, J. O. Durell, Clk., plans an election to vote $10,000 bonds for the purchase of light and power plant equipment.

Calif., Fresno—County plans an election to vote $350,000 bonds for courthouse annex, including installation of a new steam plant.

Calif., Los Angeles—W. H. Dillehunt, et al, 709 Commercial Exchange Bldg., is having preliminary plans prepared for the construction of an ice rink at Vermont Ave. Estimated cost $200,000. C. R. Selkirk, American Bank Bldg., is architect.

Calif., Los Angeles — Pacific National Bank, 652 South Olive, is receiving bids for the construction of a 12 story bank and office building, including steam heating system and 3 electric elevators, at N. W. cor. 9th and Hill Sts. Estimated cost $1,500,000. Morgan, Walls & Clements, 1124 Van Nuys Bldg., are architects.

Calif., Los Angeles — A. Soiland, 1407 South Hope St., awarded contract for the construction of a 9 story office building at 1405-07 South Hope St. to C. L. Peck, H. W. Hellman Bldg., $600,000. Steam heating system and 3 electric elevators will be installed.

Calif., Los Angeles—Sun Realty Co., 742 South Hill St., is having plans prepared for the construction of two, 13 story, hotel and store Luildings, including steam heating system and 3 electric elevators in each, at 7th and Hartford and 7th and Lebannon Sts. Estimated cost $1,000,000 and $900,000 respectively. Curlett and Beelman, 408 Union Bank Bldg., are architects.

Calif., Los Angeles—A. C. Vaughan and Associates, had plans prepared for the construction of a 12 story hotel including steam heating and vacuum systems and 3 electric elevators, on Carondelet St. Estimated cost $800,000. The Postle Co., 631 Van Nuys Bldg., are architects and engineers.

Calif., Newport Beach — City is having preliminary plans prepared for the extension of domestic water system, including an additional unit for pumping plant, etc. Estimated cost $200,000. P. E. Kressly, H. W. Hellman Bldg., Los Angeles, is engineer.

Calif., Oakland—East Bay Utility Dist., is having plans prepared for development of the Mokelumne River project for mountain water supply system, including pumping station, with 200 to 300 ft. lift, near Pittsburgh. Total estimated cost $25,000,000, bond issue of $35,000,000 voted. A. P. Davis, 505 17th St., Oakland, is engineer.

Calif., Sacramento—San Francisco Drugless Hospital Assn., c/o Shea & Shea, 454 Montgomery St., San Francisco, Archts., is having plans prepared for the construction of a hospital at 21st, 22nd, Q and R Sts., here. Estimated cost $500,000.

Calif., San Francisco—G. A. Schaeffer, et al., 560 Sutter St., are having plans prepared for the construction of a 10 story apartment house at Pacific Ave. and Laguna St. Estimated cost $500,000. S. L. Hyman, 68 Post St., is architect.

Calif., Santa Cruz—F. E. Morgan, c/o Walker & Eisen, Great Republic Bldg., Los Angeles, Archts., is having preliminary plans prepared for the construction of a 10 story, office and stores building at Church St. and Pacific Ave. Estimated cost $1,500,000.

Calif., Watsonville—Union Ice Co., 354 Pine St., San Francisco, is having plans prepared for the construction of a cold storage and ice plant. Estimated cost $350,000. Davis - Heller - Pearce, Inc., Delta Bldg., Stockton, is architect.

Fla., Ocala—Hockenbury System Inc., 200 North 3rd St., Harrisburg, Pa., plans the construction of a hotel, here. Estimated cost $500,000.

Ill., Chicago—H. K. Holsman, 37 South Wabash Ave., Archt. and Engr., is receiving bids for the construction of a 4 story apartment at 7853 South Shore Drive, for A. H. Ranes, 11 South La Salle St. Estimated cost $500,000.

Ill., Chicago—Lowenberg & Lowenberg, 111 West Monroe St., Archts. and Engrs., are receiving bids for the construction of a 3 story theater and office building at 5900 Kedzie St., for C. M. Wasson, 343 South Dearborn St. Estimated cost $900,000.

Ky., Louisville—F. G. Breslin, 32nd and Market Sts., plans the construction of a 14 story office building at Broadway and 3rd St. Estimated cost $2,500,000. Architect and engineer not announced.

Ky., Louisville — U. S. Engineer's Office, E. Kanzler, Pur. Agt. is in the market for an air compressor, locomotive type; 3 generators, electric, steam or turbo, 1½ or 2 kw., 120 v.; for dam in the Ohio River, at Olmstead, Ill.

Md., Baltimore — J. E. Sperry, Calvert Bldg., Archt., will receive bids until May 18th for the construction of a 7 story hospital at Monument and Rutland Aves., for Hebrew Hospital & Asylum Association. Estimated cost $800,000. H. F. Doeleman, 507 North Charles St., is engineer.

Mass., Holyoke—Holyoke Water Power Co. plans the enlargement of plant on the Connecticut River. Estimated cost $100,000. First unit will be started at once. Estimated cost $20,000.

Mich., Detroit—Carey & Esselstyn, 2539 Woodward Ave., Archts., will soon award contract for the construction of a 9 story hospital annex at Clinton St. Estimated cost $1,000,000. Former bids rejected.

Mich., Detroit—Detroit Railway & Harbor Terminals Co. Buhl Bldg., plans the construction of an 8 story, 180 x 650 ft., freight terminal on West Jefferson Ave. The plans include a 200,000 sq.ft. cold storage plant and detached power plant. Complete cold storage equipment, and conveying machinery will be purchased. Estimated cost $4,500,000. A. Kahn, 1000 Marquette Bldg., is architect.

Minn., Winthrop—City, A. L. Malm, Clk., will receive bids until May 25th for pumping equipment, electric distribution system, etc. Estimated cost $25,000.

Mo., St. Louis—Ambassador Investment Co., c/o S. Koplar, 5750 Waterman St., awarded contract for the construction of a 15 story hotel and apartment at Union Blvd. and Pershing Ave. to Boaz-Kiel Construction Co., Chouteau Trust Bldg. Estimated cost $1,000,000.

Mo., St. Louis—H. H. Machine & Motor Co., 4216 West Easton Ave., is in the market for air compressor and tank 6 in. bore or medium size.

Neb., Bloomfield—City plans an election May 26, to vote $50,000 bonds for the construction of an electric light plant and distribution system.

N. J., Camden—City plans the construction of pumping stations in various parts of the city, also sewage disposal plants. Total estimated cost $2,338,000. Remington & Vosburg, 509 Cooper St., are engineers.

N. Y., Brooklyn — Bricken Construction Co., 300 Madison Ave., New York City, will build a 26 story office building at Court and Remsen Sts., here. Estimated cost $5,500,000. Schwartz & Gross, 347 5th Ave., New York City, are engineers. Owner is general contractor.

N. Y., Buffalo—P. G. Pullman, 621 Walden Ave., is in the market for a 3 ton ice machine.

N. Y., Lackawanna—City, N. A. Hegedus, Clk., will receive bids until June 5, for the construction of a sewage disposal plant and pumping station. F. W. Wing Co., 1314 Prudential Bldg., Buffalo, is engineer.

N. Y., New York — Courtland Bishop Corporation, c/o Carrere & Hastings, 52 Vanderbilt Ave., Archts. and Engrs., is having plans prepared for the construction of an apartment including steam heating system, at 6th Ave. and 55th St. Estimated cost $1,500,000.

N. Y., New York—J. Goldstein and I. Teitelbaum, c/o G. F. Pelham, 200 West 72nd St., Archt. and Engr., are having plans prepared for the construction of a 15 story apartment hotel including steam heating system at 242 West 76th St. Estimated cost $2,000,000.

N. C., Greensboro — C. O. Yoakum, 17 East 42nd St., New York, awarded contract for the construction of an 8 story hotel, here to Barras Construction Corp., 366 Madison Ave., New York. Estimated cost $1,300,000. Sharpe, Bready, & Peterkin, 50 East 42nd St., New York, Engrs. and Archts., will award contract for the steam heating system.

O., Cleveland—Elyria Iron & Steel Co., 232 East 131st St., awarded contract for the construction of factory addition, including boiler house, etc., to A. A. Lane Construction Co., 1869 East 55th St. Estimated cost $200,000.

O., New Philadelphia—City Council plans the construction of a new 750 kw. power plant. Estimated cost $50,000 to $60,000.

Okla., Frederick — City, Mayor Gamble, plans the construction of an electric power plant, with complete equipment. Estimated cost $160,000.

Okla., Okeechobee — City Council, City Hall, R. P. Fletcher, Clk., will receive bids until June 1, for the construction of waterworks improvements, including m.g.d. filter plant and pumping station. Equipment includes two 1,000 g.p.m. intake pumps and motors, or other drive, complete with starting and control equipment; one 350 g.p.m. and one 750 g.p.m. service pumps with motors etc., hydraulic lift gate valves, etc. F. E. Lawrence is engineer.

Ore., Portland—Balfour, Guthrie & Co., 353 Oak St., awarded contract for the construction of a 100,000 bu. capacity grain elevator, at Pelly Grove and Ferant St., to L. H. Hoffman, Gasco Bldg. $100,000. Owner will soon be in the market for machinery including engines, boilers, conveyors, etc.

Pa., Norristown—Grater-Codey Co., Main and Astor St., plans the construction of a boiler house including boilers, etc., at plant. W. E. Dyer, Land Title Bldg., Philadelphia, is engineer.

Pa., Norristown — Norristown Woolen Mills, 335 East Main St., plans the construction of a boiler house including boilers, etc., at 330 East Main St. W. E. Dyer, Land Title Bldg., Philadelphia, is engineer.

Pa., Retreat — Luzerne County, Wilkes-Barre, will build a 45 x 90 ft. power house, at the Luzerne County Mental Hospital, here. Work to be done under the supervision of L. T. Klauder, Builders Trust Bldg., Philadelphia, Engr.

Tenn., Union City — Bd. of Aldermen plans additions and extensions to electric light and water plant. Estimated cost $25,000.

Tex., Beaumont—Jefferson County, B. B. Johnson, Judge, will receive bids until May 28 for motor operating machinery, electric lighting ,etc. for draw span bridge across the Neches River, here. A. C. Love, Beaumont, is county engineer.

Tex., San Angelo—West Texas Utilities Co. is taking bids for the construction of a 70 ton capacity ice plant, including machinery. Estimated cost $60,000. Adams & Adams, Gibbs Bldg., San Antonio, are engineers.

Tex., San Antonio—J. Oppenheimer, et al, 309 Madison St., will receive bids after May 16th for the construction of a 6 story office and theatre building at St Marys and Commerce Sts. Estimated cost $1,500,000. Kelwood Co., Travis Bldg., is architect and engineer.

Tex., Victoria—City voted $90,000 bonds for the construction of a waterworks system and electric light plant. $31,000 bonds have been already voted for light plant. S. S. Sitterle is city attorney.

Vt., Burlington—U. S. Treasury, Department, Washington, D. C., J. A. Wetmore, supervising architect will receive bids until June 10, for furnishing and installing 2 horizontal, smokeless, firebox, heating boilers, with portable settings, at the post office and custom house, here.

Wis., Green Bay—Northern Cold Storage Co., North Broadway, awarded contract for the construction of a cold storage plant and a boiler house at Broadway to L. M. Hansen, 113 West Walnut St. Estimated cost $50,000. Owner is in the market for refrigeration equipment.

Wis., Milwaukee—Empire Fish Co., 2417 Uliet St., awarded contract for the construction of a refrigerating plant to A. W. Riesen, 961 North Water St. Estimated cost $40,000. Owner is in the market for a motor-driven refrigeration system.

Wis., Waukesha—Waukesha Jelly Powder Co., Broadway, and East Ave., is in the market for machinery and electric motors for proposed new plant on Cutler St. Estimated cost $25,000. Eckerman & Ruddell, 279 Layton Blvd., Milwaukee, are engineers.

Que., St. Jerome — W. H. Dyer, Land Title Bldg., Philadelphia, Engr., is taking bids for the construction of a 26 x 46 ft. power house, for the Regent Knitting Mills, here. Babcock & Wilcox boilers will be purchased.